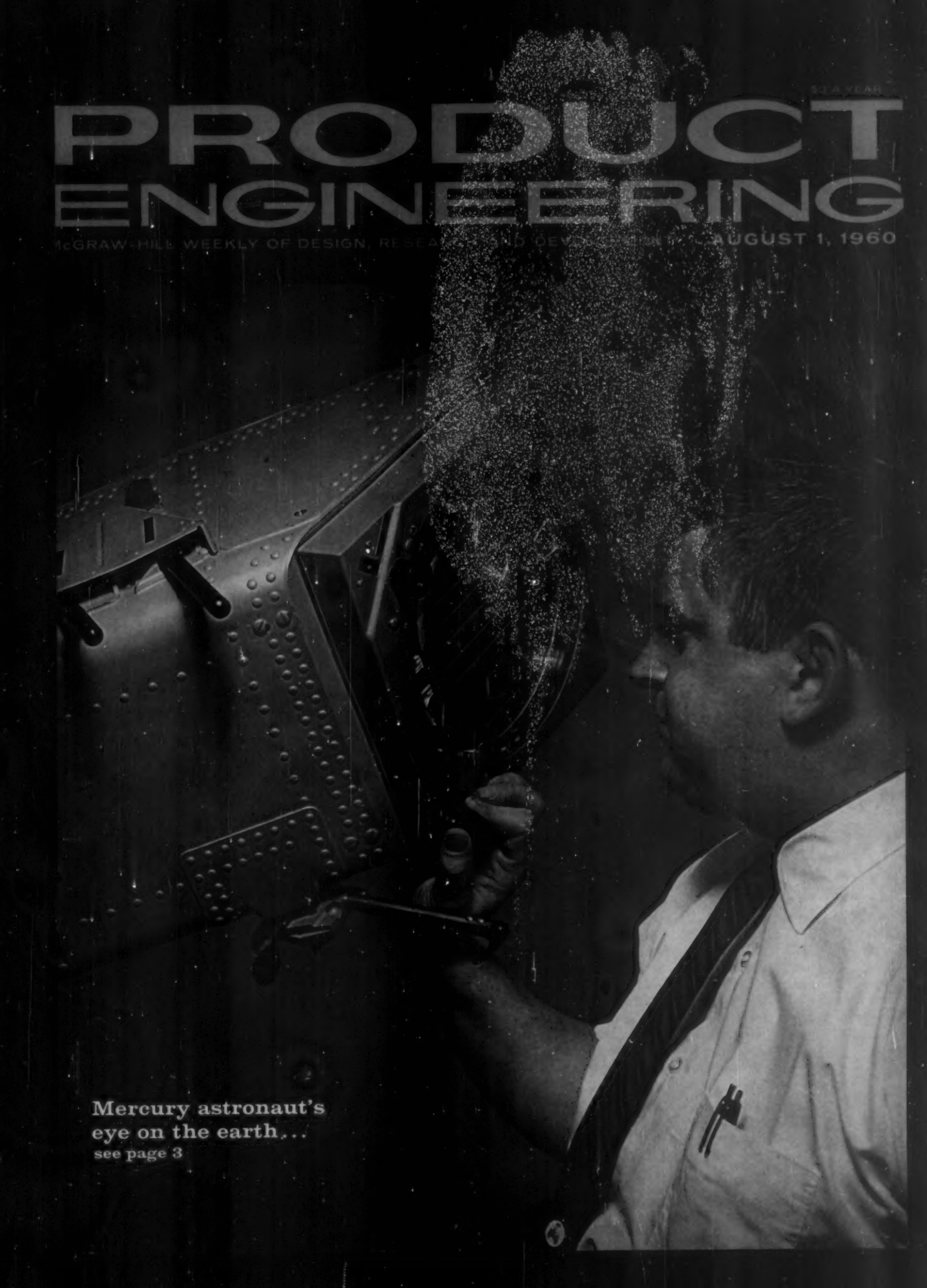
$3 A YEAR

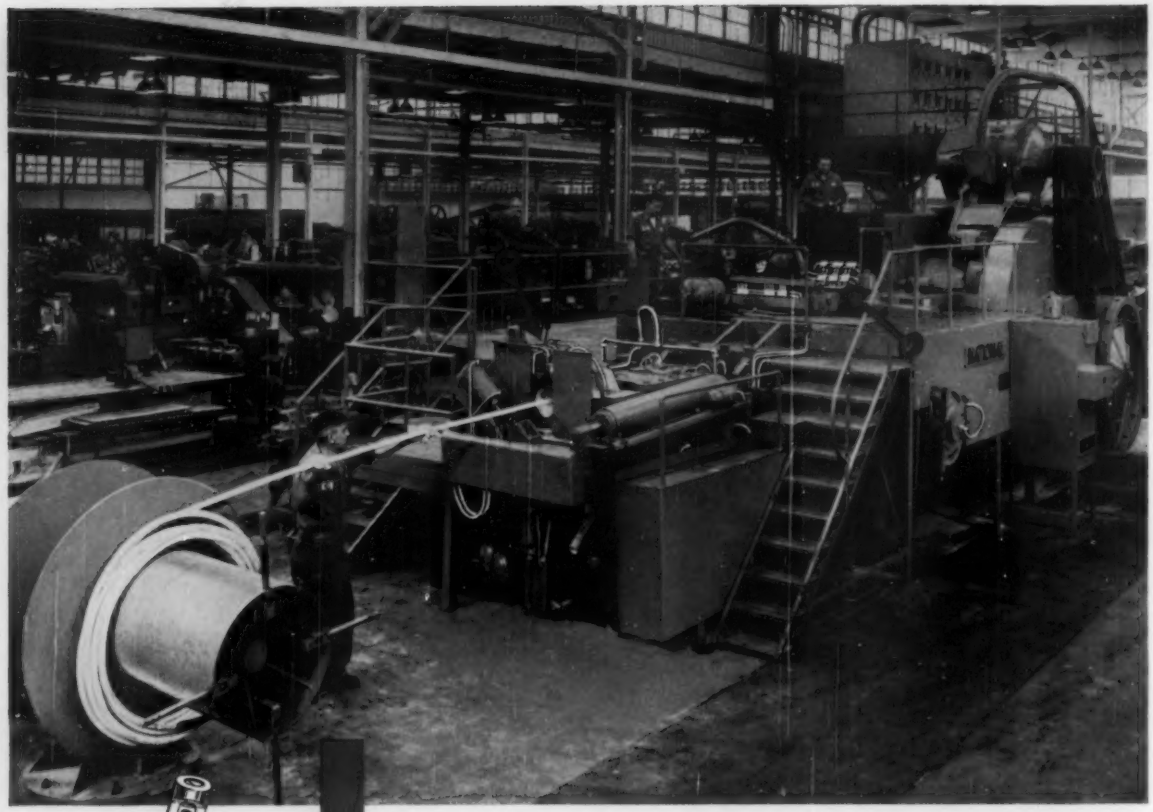
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · AUGUST 1, 1960



Mercury astronaut's eye on the earth...

see page 3



FARVAL—Studies in Centralized Lubrication No. 238

Farval automatically lubricates 138 bearings on world's largest Boltmaker

It's a 1¼-inch cold forger, designed and built by National Machinery Co. for the Cleveland Cap Screw Co., Cleveland, Ohio. This versatile machine automatically produces hex head cap screws. It draws steel rod to wire size, cuts it to proper length, extrudes the blank, heads, trims the head, points the end and then rolls on threads, all this at the rate of 38 complete screws per minute.

A Farval timeclock-controlled, motor-driven lubricating system guarantees against failure of the machine's 138 vital bearings, as well as supplying spray lubrication for the cold-forger's chain drive. If bearings should fail on such a high output machine—production costs skyrocket, profits take a nose-dive.

Write for revised Bulletin 28-7, which shows how Farval can extend both bearing and gear life on new machinery—as well as on older equipment now in use.

Farval Division • Eaton Manufacturing Company
3279 East 80th Street • Cleveland 4, Ohio

KEYS TO ADEQUATE LUBRICATION

Wherever you see the sign of Farval—familiar valve manifolds dual lubricant lines and central pumping station—you know steel mill equipment is being properly lubricated.

CIRCLE 201 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

August 1, 1960 Vol. 31, No. 31

FEATURED:

DEPARTMENTS:
INTERESTING TO NOTE 3
COMING NEXT WEEK 4
DEVELOPMENTS TO WATCH 6
WHAT'S NEW IN RESEARCH 11
FROM WASHINGTON 12
THE ENGINEERING WEEK 16
POINTS OF VIEW 20
READER TO EDITOR 22
COMING EVENTS 23
FYI PERSONAL 24
HORIZONS 29
SIGNIFICANT COMPONENTS 55
DESIGN LITERATURE 65
ADVERTISERS INDEX 73
READER SERVICE CARDS 75

EASIER WAY TO DESIGN JOURNAL BEARINGS . . . Dr G S A Shawki, Cairo Univ
Author supplies helpful design charts along with new equations..... 31

BRAZED JOINTS TAKE HIGH TEMPERATURES . . . J C Reeves, Marquardt Corp
Roundup of applicable metals, and details on furnace method..... 40

BETTER OPERATING PROCEDURES . . . D P Simonton, RCA
How to write instructions and get the most good from them..... 46

10 WAYS TO PREVENT PISTON ROD ROTATION . . . D Rowan
To the common methods, author adds his V-groove ball guide..... 48

6 WAYS TO PREVENT OVERLOADING . . . P C Noy, Nicromatic Ltd
These "safety valves" give way before machinery jams..... 51

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS:
Beryllium gives titanium a hard case, soft core..... 6
New mold-cure method for better silicone rubber parts..... 6
Transducer materials call for new design approach..... 11
Silicone coatings developed for up to 1400 F..... 55

MECHANICALS:
Baby pinch valve featured in new conveyor system..... 6
Formed-in-place lubricants for 1000-F service..... 10
Miniature 4-way coupling tolerates misalignment..... 55
Press-in nut gives liquid-tight seal..... 55

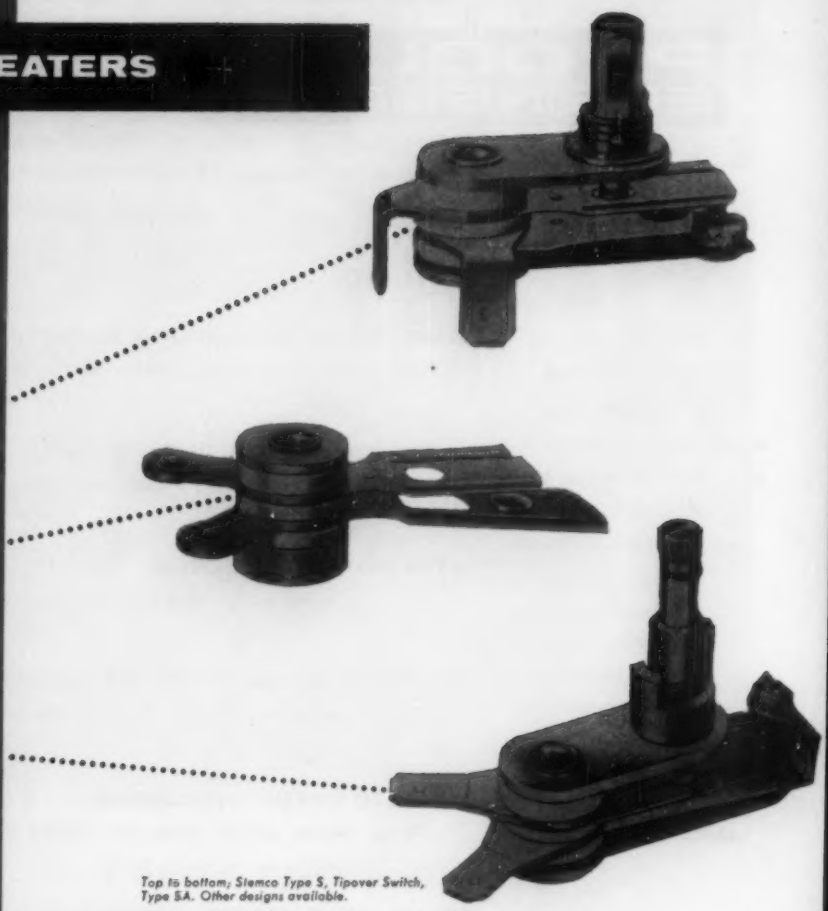
ELECTRICAL:
New capacitors for —65 F to 400 F..... 6
Coating of noble metal improves electrical components..... 10
Earth-space-earth communications system expected by 1970..... 17
Meter shows maximum reading received..... 55

PRODUCT DESIGN:
Cutoff prevents overloading of hoists..... 37
Periscope will guide man in space..... 38

TESTS:
Precision thermometry shows effects of trace elements..... 11
Mossbauer effect: key to precision measurement..... 11
Submarine jet propulsion studied by Navy..... 12
Artic ice city to test equipment..... 12

GENERAL:
Story of a hoax—when "perpetual motion" turned gears..... 4
Aperture cards for space-age drawings..... 15
Annual car-model changes going out?..... 19

FOR PORTABLE AIR HEATERS



Top to bottom; Stemco Type S, Tipover Switch, Type SA. Other designs available.

IT'S STEMCO THERMOSTATS

No wonder leading manufacturers of portable air heaters specify Stemco thermostats. For Stemco thermostats give long-life reliability that eliminates service headaches . . . are quickly, easily installed . . . are competitively priced. Our application engineering service is eager to help you solve your thermostatic control problem, whether it involves design, production or cost. Try us *now*.

AA-9041

STEVENS *manufacturing company, inc.*

P. O. Box 1007 • Mansfield, Ohio

STEMCO

THERMOSTATS

Other appliances, too, such as automatic coffee makers, skillets, saucepans, griddles, inhalers, fans, steam and flat irons, roasters, fry kettles, refrigerators, butter warmers, waffle irons, electronic and avionic applications.

INTERESTING TO NOTE

On our cover—the periscope designed by Perkin - Elmer Corp for the manned Mercury Capsule. Project engineer John Shanley shows how an astronaut will be able to view the earth from horizon to horizon. How the unit operates is discussed in detail on page 38.

A periscope, usually associated with submarines, was first actually used on a surface ship. During the Civil War, the Union monitor Osage ran aground in the Red River and came under heavy fire from Confederate shore batteries. Rather than allow his men to remain on deck during the bombardment, the Osage's captain directed gunfire by a crude periscope made from a piece of pipe and two mirrors. However, the incident made little impression upon Navy scientists at the time, for the next periscope development didn't occur until many years later when a civilian engineer felt that submarines should have "eyes."

Submarines were first used during the Revolutionary War; but had no way of sighting when submerged. In 1902, however, Simon Lake, a mechanical engineer and naval architect, realizing that cruising with a conning tower exposed presented too great a target, set out to design and build a submarine periscope. He thought of using a tube with two prisms to display the surface scene through an eyepiece or on a screen made of white cloth. One day he spied a large box of assorted lenses in the window of a shop in Bridgeport, Conn. He bought them all, took them home and tried matching various combinations. After much experimenting he did hit upon a combination that worked, but an office boy accidentally dropped and broke the instrument.

Rather than again undergo the arduous routine of trial and error, Lake sought assistance from a faculty member at [illegible]s Hopkins University. After listening to Lake's descriptions of the complex optical device, the professor said, "Sorry to disappoint you, but you are trying to do the impossible." When Lake explained that he had already accomplished "the impossible" the professor reconsidered, retired to his study, and emerged the next day with the optical principle on which today's periscope is based. This first instrument, called an "omniscope," was rather crude when compared to the complex optical instrument on the modern submarine.

Although these early periscopes solved many of the submariner's problems, they were no better than the men who used them. In 1904, the A-1, first British submarine equipped with a periscope, was cruising beneath the surface. The conning officer, failing to scan the entire horizon, didn't see the steamer Berwick Castle closing rapidly on a collision course. The resultant crash sent the A-1 to the bottom with her entire crew. continued, next page

PRODUCT ENGINEERING

ELMER J TANGERMAN *editor*

STANLEY J ALLING *publisher*

ROBERT W CARSON *managing editor*
RICHARD M KOFF *assistant managing editor*

ROBERT E ABBOTT *senior associate editor*

JOHN KOLB *associate editor*
NICHOLAS CHIRONIS *associate editor*
FORD PARK *associate editor*
ROBERT PRENTISS *associate editor*
ANNESTA R GARDNER *associate editor*
WILLIAM GILMAN *associate editor*
FRANKLIN D YEAPLE *associate editor*
JOSEPH J KELLEHER *associate editor*
DOUGLAS C GREENWOOD *associate editor*

BENEDICT A LEERBURGER, JR *assistant editor*
PHILLIS B SWEED *assistant editor*
DORA K MERRIS *assistant editor*
HERBERT KEE *assistant editor*
CHARLES J LYNCH *assistant editor*

FREDERICK MARICH *assistant editor*
JOHN PRICE *assistant editor*
FRANCIS E HALL *assistant editor*
BRUCE H FRISCH *assistant editor*

FELIX GIORDANO *Detroit*
SETH PAYNE *Washington*

RICHARD E ROOMAN *art director*
E G LOADER *associate art director*
ANGELA M GIACIN *assistant art director*

NORMA J VAN NESS *production supervisor*
LILLIAN M WITHAM *assistant supervisor*

ROBERT E BRUCKNER *consulting editor*
DEXTER KEEZER *director, economics dept*

C C KANE *reader service manager*

McGraw-Hill News Bureaus

JOHN WILHELM *director*
MARGARET RALSTON *assistant*

GEORGE B BRYANT, JR *Washington*
DONALD MacDONALD *Detroit*
ARTHUR ZIMMERMAN *Cleveland*
STEWART W RAMSEY *Chicago*
JENNESS KEENE *San Francisco*
KEMP ANDERSON *Los Angeles*
RAY BLOOMBERG *Seattle*
B E BARNES *Atlanta*
MARVIN REID *Dallas*
JOHN TUNSTALL *London*
ARTHUR ERIKSON *Paris*
GENE DI RAIMONDO *Milan*
RAYMOND SHAH *Zurich*
CURT AGREN *Stockholm*
ERNEST CONINE *Moscow*
JIM MORRISON *Bonn*
SOL SANDERS *Tokyo*
JOHN YAMAGUCHI *Tokyo*

A McGRAW-HILL PUBLICATION

August 1, 1960
Vol. 31, No. 31

Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N. Y.
Telephone: LOngacre 4-3000
Teletype: TWX NY 1-1636
Cable Address: MCGRAW-HILL, NY

PRODUCT ENGINEERING is published weekly — with an additional Design Digest Issue in Mid-September, by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), founder. US subscription rates for individuals in the field of the publication, $3 per year, single copies 50 cents; Canadian subscriptions $5 per year; foreign $25 per year, payable in advance. Printed in Albany, NY; second-class postage paid at Albany, NY. Title ® registered at US Patent Office. © Copyright 1960 by McGraw-Hill Publishing Company, Inc. All rights reserved, including the right to reproduce the contents of this publication, either in whole or in part.

UNCONDITIONAL GUARANTEE. The publisher, on written request, agrees to refund the part of the subscription price applying to the remaining unfilled portion of the subscription if editorial service is unsatisfactory. PRODUCT ENGINEERING articles are indexed in both the Applied Science and Technology Index and the Engineering Index. PRODUCT ENGINEERING publishes its own semi-annual index. Copies are obtainable on request to the editor.

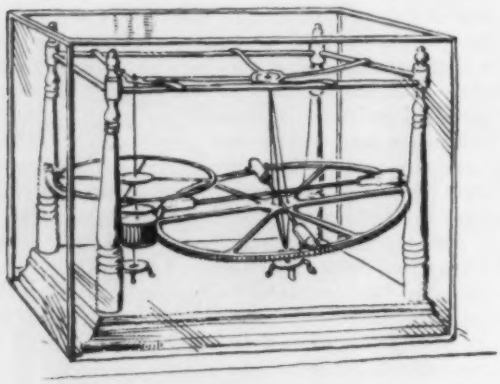
POSTMASTER Please send form 3579 to Fulfillment Manager, PRODUCT ENGINEERING, 330 W. 42nd St., New York 36, NY.

←CIRCLE 2 ON READER SERVICE CARD

The Wheel Goes 'Round and 'Round

Gadgetry has long been a strong point in selling commercial products. Automobile dashboards have taken on the look of a pilot's panel; a push of a button can change the station on your auto's radio or lubricate the entire car. Opening a can of beans has become an automated operation, while some washing machines are programed like an IBM computer. (For a discussion of automation in consumer products, see p 20.)

In 1856, a man named E. P. Willis dreamed up a



gadget that brought him large profits—but from showmanship rather than practical application. It consisted of a crude planetary gear system which revolved without a visible source of power. Willis placed his array of gears within a glass case, rented a second floor room on lower Broadway in New York and began exhibiting his perpetual-motion machine. He hung the following shingle: "Perpetual motion! The greatest discovery ever yet made. Call and see it—and our word for it, you will not regret the trouble. Admission 25 cents." People flocked around the glass case watching the gears revolve slowly, seemingly without any external power. A local journalist reported, "We urged the exhibitor several times to remove the case and give us a fair chance either to satisfy ourselves that it was a genuine 'perpetual motion' or to detect the trick, but he positively refused. He said it was a very delicately constructed apparatus, and was fearful that it might be injured if the case were taken off." The novelty of Willis' gadget soon wore thin in New York but he turned his "great discovery" into a traveling road show and again reaped a profit. —Benedict A Leerburger Jr

SIDELIGHT

"Leave your engineering at the office!" our wives shout desperately—and often they're right. We know one doctor of engineering who delayed hanging a picture in a new home for weeks until his wife found out he planned to borrow an X-ray machine from the lab to help find the studs. But the neatest bit of analysis we know was done by a lady heat-transfer specialist. A regular problem in graduate school courses involves calculating the transient heat flow to a roast beef. During her first year of marriage the lady found herself hostess to a Thanksgiving dinner—and no experience in cooking turkeys. It didn't stop her for a minute. She sat down with pencil and paper, adjusted a constant or two, and solved for a cooking time that (we're told) produced a masterpiece—crisp on the outside, juicy on the inside, and altogether a success.

NEXT WEEK IN PRODUCT ENGINEERING

. . . **High-strength Aluminum Alloys**
An evaluation of a newcomer—how it stacks up against other members of the high-strength family.

. . . **When Plastic Cams Are Better**
In production quantities of 100 or more, plastic cams can be molded to closer tolerances and higher uniformity than steel ones machined one at a time.

. . . **The Simple Math of the Response Equation**
No matter what your field, this equation is bound to be useful.

. . . **Shortcut to Designing Torsion Bars**
Two-in-one nomograph speeds calculation of dimensions, stress or spring rate for both round and rectangular bars.

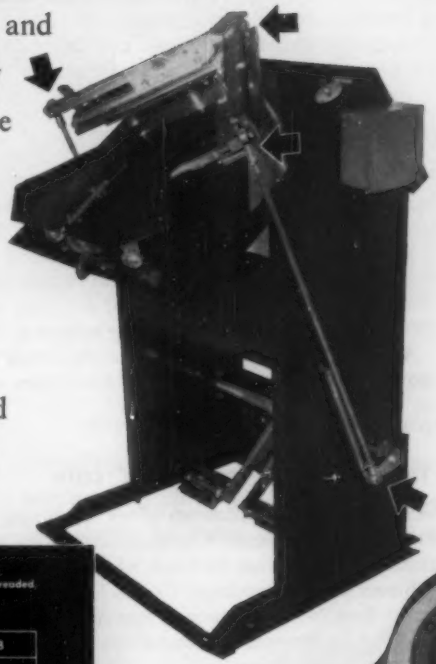
. . . **Your Choice of Recycling Timers**
When you have to design a time delay into an electrical control circuit the answer will probably be one of these five types.

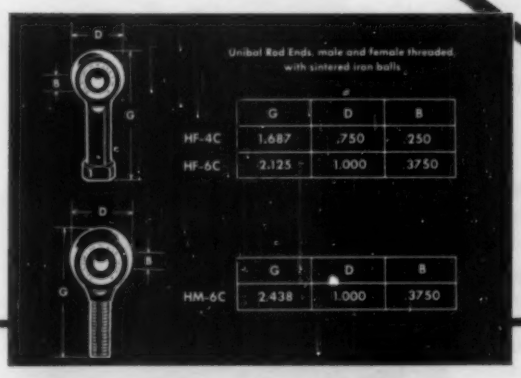
How to do it Better for less...

with HEIM Unibal®

SPHERICAL BEARING ROD ENDS

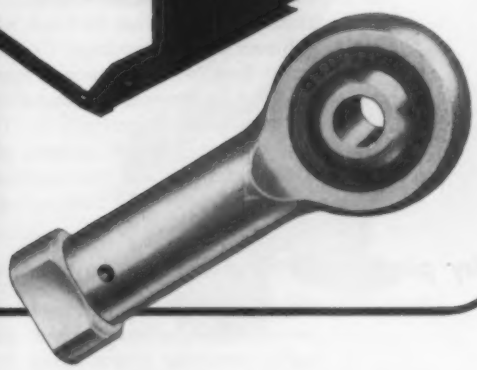
This is the Collar Shaping and Pressing Machine made by the Reece Folding Machine Company, which is a low-priced, manually operated device used in the shirt trade for shaping and pressing collars after they are sewed together, but before being attached to the shirt.





	G	D	B
HF-4C	1.687	.750	.250
HF-6C	2.125	1.000	.3750

	G	D	B
HM-6C	2.438	1.000	.3750



Unibal Rod Ends are used in five places, and were chosen for some carefully-thought-out reasons.

- *Unibal ball joints lower the machining and assembly cost.* A male Unibal is used at the fulcrum of the triangular pressing lever at top center. This allows the pressing plates to be easily lined up with the mating surface without expensive machining to close tolerances.
- *Long wearing qualities reduce replacement costs.* Reece says, "We have been using Unibal rod ends in our machines since 1947, and as far as we know, none have had to be replaced because of wear.
- *Solve design problems economically.* The use of Unibal "gets us out of some tough design problems quite economically, simplifies co-operating parts and makes final assembly easier."
- *Maintain easy, smooth action.* Heim Unibal rod ends are used to transmit motion from the lower shaft to the pressing plates between levers moving in arcs in different planes. They maintain the easy action necessary to manual operation.
- *Correct misalignment in all directions.*

The high quality and special advantages of Unibal Spherical Bearings and Rod Ends can save you time and money in the assembly of your machines. Ask our engineering department how. Send for the Heim complete catalog.

THE HEIM COMPANY Fairfield, Connecticut

ALL HEIM BEARINGS ARE AVAILABLE THROUGH THE LEADING BEARING DISTRIBUTORS IN THE U. S. AND CANADA

DEVELOPMENTS TO WATCH . . .

One-step molding and curing to improve silicone rubber parts

A press-curing system which adapts the technique of injection molding to silicone rubber parts is being developed by GE's Silicone Products Dept in cooperation with Lewis Welding & Engineering. The advantages: shorter molding cycles (10 to 30 sec at 450 F, 30 to 90 sec at 390 F), improved resistance of the rubber to reversion because the amount of curing agent required can be reduced, and improved resistance of finished products to compression-set.

Optimum molding cycles are now being investigated, as are possible extensions of the technique to other polymer systems.

New capacitors for −65 F to 400 F

Plastic film condensers claimed to have excellent stability, very high insulation resistance, a low power factor, and an operating range from −65 F to nearly 400 F are being introduced by Telegraph Condenser Co, London, England.

These are PTFE fluorocarbon units, housed in tinned brass tubes with ceramic end disks, and hermetically sealed with a special high-temperature solder. Insulation resistance is on the order of 20,000 megohm, at room temperature, and not less than 1000 megohm at 398 F. Working voltage is 500 v dc.

Also new from TCC: paper tubular condensers for −40 F to 212 F, housed in epoxy-phenolic, resin-bonded, glass fiber cases; and metallized polyester film condensers for the −40 F to 250 F range.

Beryllium gives titanium hard case, soft core

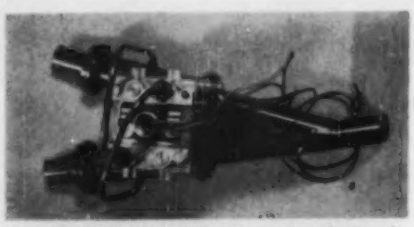
New, heat-treatable titanium alloys containing beryllium and molybdenum are being developed by Imperial Chemical Industries Ltd; and, says ICI, they can be heat-treated to high surface hardness, while retaining ductility in the core.

Binary alloys containing 0.6 to 1.2% Be and having a hardness of 228-241 Vhn before heat treatment show a case hardness on the order of 500 Vhn after heat treatment, while the core hardness drops to less than 200. Yield strength is in the 100,000 psi range, and elongation 5 to 11%.

Even greater surface hardness and depth of penetration are being obtained with test heats of ternary and quaternary alloys containing 0.25 to 2% molybdenum and/or silicon, and they hold their surface hardness at temperatures at least to 700 F.

Baby pinch valve featured in new conveyor system

Key to successful operation of a new low-volume, medium-pressure pneumatic conveying system being developed by the US Dept of Agriculture is the midget 3-way pinch valve pictured here. The system, which uses a double-piston rotary type blower and a rotary airlock, operates at pressures under 20 psi, and uses small-diameter (1 to 4 in.) pipe.



THREE-WAY VALVE is designed for installation on small-diameter lines, can be remotely operated through solenoid system.

The valve, air-operated and electrically controlled, meters flow from the main line into branch lines. It consists of a metal tube with a collapsible rubber liner. Compressed air injected between the lines and the casing collapses the liner and plugs the line.

Biggest design problem for this smallest-size unit was abrasive wear at the constricted, downstream end. But, says H. B. Puckett of USDA's Engineering Experiment Station, Urbana, Ill., a new reinforced rubber sleeve developed by Firestone Tire & Rubber Co promises to prolong valve life considerably. continued, p 10

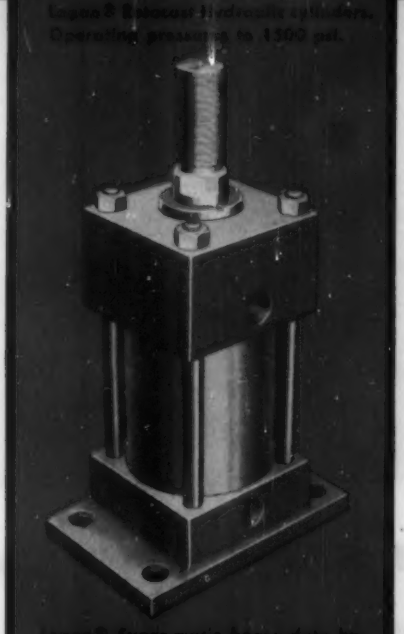
KING SIZE?

choose

Logan

Hydraulic Cylinders

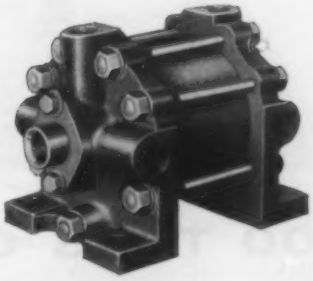
Logan® Rotocast Hydraulic cylinders. Operating pressures to 4500 psi.



Logan® Super-matic heavy-duty hydraulic cylinders. Operating pressures to 2500 psi.

Any size, any pressure, any stroke, any mounting to meet your specific need. Our engineering staff will be glad to assist you in helping to meet your design problems.

Logan 750 series rotating and nonrotating hydraulic cylinders. Operating pressures to 750 psi.



MEMBER: *National Machine Tool Builders' Assn.*
National Fluid Power Assn.

FREE.....

Send for your copy of A down-to-earth 20-page booklet on the "rights" and "wrongs" in setting up and servicing air and hydraulic equipment.

LOGANSPORT MACHINE CO., INC., 812 CENTER AVENUE, LOGANSPORT, INDIANA
PLEASE SEND COPY OF CATALOG

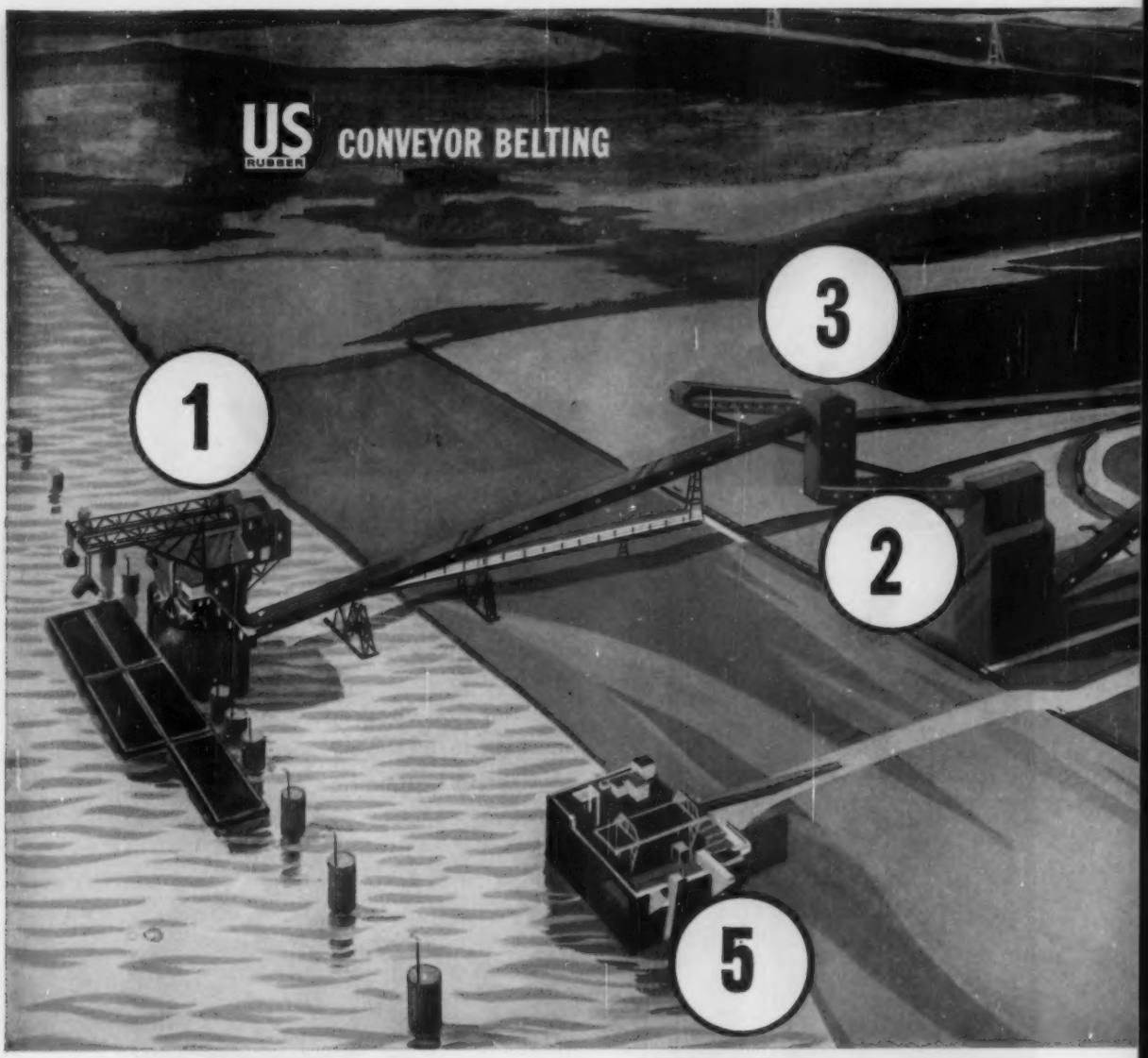
- ☐ 100-1 Air Cylinders
- ☐ 100-2 Mill-Type Air Cyls.
- ☐ 100-3 Air-Draulic Cyls.
- ☐ 100-4 Air Valves
- ☐ 100-5 Logensquare Cyls.
- ☐ 300-2 Presses
- ☐ Facts of Life
- ☐ 200-1 Hyd. Power Units
- ☐ 200-2 Rotocast Hyd. Cyls.
- ☐ 200-3 750 Series Hyd. Cyls.
- ☐ 200-4 and 200-7 Hyd. Valves
- ☐ 200-6 Super-Matic Cyls.
- ☐ 300-1 Chucks
- ☐ ABC Booklet
- ☐ Circuit Rider

TO:

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____



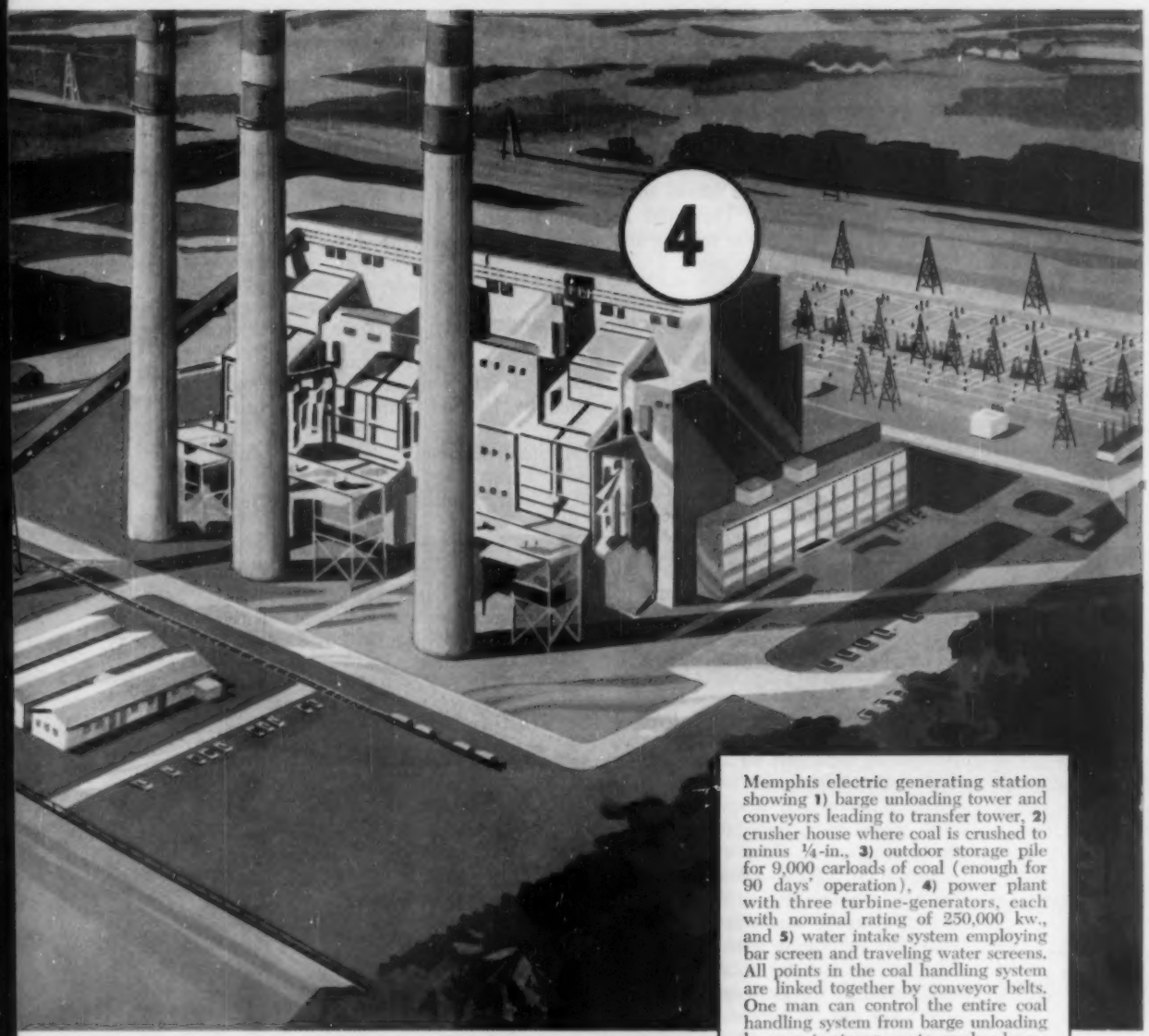
2,200 TONS OF COAL PER HOUR...all

The City of Memphis (Light, Gas & Water Division) operates the largest single steam power plant built to date for a municipality.

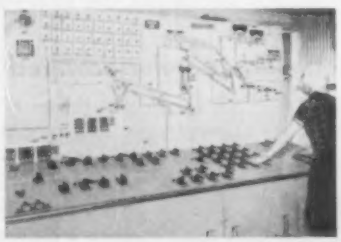
Link-Belt Company built and installed the mechanical conveyor system that conveys coal *from barge to transfer house, from transfer house to storage and from transfer house to crusher to bunkers.* U.S. Rubber constructed and furnished all belts conveying coal from transfer tower to the main power plant. Six conveyors in all are equipped with U.S. Conveyor Belts, including two 48"-wide U.S. Giant® Belts.

This extensive system is all controlled by one man operating the control panel in the transfer house.

The troughability and the training of the U.S. Rubber Belts result in efficient, economical operation, long life and freedom from maintenance. "U.S." Belts have long been noted for having these qualities. The inclusion of "U.S." Belts for this massive power plant is just one more unequalled instance that has made



Memphis electric generating station showing **1)** barge unloading tower and conveyors leading to transfer tower, **2)** crusher house where coal is crushed to minus ¼-in., **3)** outdoor storage pile for 9,000 carloads of coal (enough for 90 days' operation), **4)** power plant with three turbine-generators, each with nominal rating of 230,000 kw., and **5)** water intake system employing bar screen and traveling water screens. All points in the coal handling system are linked together by conveyor belts. One man can control the entire coal handling system from barge unloading hoppers to storage or to crusher house and bunkers. Lights and schematic diagram show portion of system in operation at any time.



controlled by one man

U.S. Rubber the foremost authority in the design, manufacture and installation of conveyor belts.

Get the advantages of "U.S." Engineering. "U.S." Engineers work directly with "U.S." Distributors or original equipment manufacturers to assure their obtaining the right belt for each type of conveying.

• • •

The most extensive belting engineering information in industry is available through your "U.S." Distributor. It will pay you to check with him.

Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

Auto drain plugs going down the drain?

Car makers are seriously thinking of eliminating the drain plug on automatic transmissions, the American Petroleum Institute's Marketing Div reports. And cooling system drains on engine blocks may soon disappear, too. The reason: too many under-hood accessories. There just isn't enough service space with the multiplicity of new gadgets like power steering and air conditioning, so some of the old standbys will have to go to make room.

Coating with noble metal improves electrical components

Brighter platinum plates that show excellent adhesion, and palladium coatings that offer improved contact properties for printed circuits used as switching elements and plug-in components—these are reported by Johnson Matthey & Co Ltd of London, England.

A new sulphate-nitrite solution, says JM, makes it possible to deposit smooth, dense, cohering coatings directly on copper, brass, silver, nickel, aluminum, and titanium. With a silver or nickel undercoat, it is also possible to obtain good results on steel, tin, zinc and cadmium.

The palladium coatings, now under test in printed circuits that replace conventional segments or slip rings in switch design, and in several computer components, are said to offer good adhesion and relatively low cost. Furthermore, says JM, they can be deposited from nearly neutral baths, and they won't tarnish. Specific gravity of the electrodeposited palladium is 11.9; resistivity at 32 F is 10.7 microohm-cm; electrical conductivity, 16%.

Formed-in-place lubricants being developed for 1000-F service

Antigalling films that are made in place—by reaction of fuming hydrocarbons in controlled atmospheres—are under development at several western research labs, among them, Western Gear Corp.

In recent tests, fume-lubricated 2-in. PD gears have operated at or near 1000 F for as long as 18 million cycles at 180,000 psi.

Says WG: "We have found that with the proper selection of materials and lubricants, machine components can be successfully operated in the 1000-F range."

But, company engineers caution: Not all bearing materials have equal affinity for such fume-lubrication systems. Far better results have been obtained with 5% Ni–2% Al nitriding steel, for instance, than with M2 and M50 tool steel bearings. Furthermore, they say this does not mean that all problems of operating in this high-temperature range can be successfully solved. "Limitations imposed by associated equipment may preclude the use of fuming hydrocarbons in a lubrication system. Also, the problem of manufacturing some allied components from compatible materials may make this system economically impracticable. They do believe though, that for many applications, this lubrication system has attractive possibilities.

Looking ahead at solar-powered thermoelectric converters

Thermoelectric theory is pretty well in hand, says R. J. Tallent of Boeing. What's needed now is a process for making thermoelectric elements far smaller than the present minimum of $\frac{1}{16}$ by $\frac{1}{4}$ in. Also needed—for solar-energy converters—are better reflectors, concentrators, absorbers, and radiators.

The latest Boeing design is a power module that will develop 10 watts at 1.2 v. Each module contains a concentrator and a generator assembly. Over-all efficiency is low—on the order of 1.6% when the hot junction is at 1120 F and the cold at 572 F. But, in this design, efficiency has been sacrificed to weight reduction. The specific weight of this module could be brought down to 300-400 lb/kw, Tallent says, but this is still much too high.

Now, though, a new design is under consideration. It would combine concentrator, radiator, electrical connections and structural elements in a single member. Very low weight-to-power ratios are expected from this concept—on the order of 20-30 lb/kw. However, the mechanical and optical problems may be sizeable. —ARG

WHAT'S HAPPENING IN RESEARCH . . .

Transducer materials call for new design approach

Magnetostrictive ferrites now being evaluated as replacements for nickel and nickel alloy elements in underwater sound transducers, promise real advantages in manufacturing ease and economy. But they'll also call for redesign of existing components in many cases.

The high resistivity of the nonmetallic ferrites makes it possible to substitute a single element for the multiple laminations now required. But before the newer materials can be put to work, a good deal must be learned about the influence of temperature and pressure on their magnetic and magnetostrictive properties.

Tests of one such material (a nickel–copper–cobalt ferrous ferrite) by Geoffrey L. Wilson of the Pennsylvania State U Ordnance Lab indicate that as the pressure is increased to 4600 psi the effective coupling coefficient decreases (from 0.21 to 0.05), suggesting that this may be close to the point of saturation magnetostriction; the resonant frequency increases (8%); and the clamped inductance decreases by 40%.

These variations appear to be considerably greater than those encountered with nickel, indicating that for some applications considerable redesign of transducers will be required for effective use of the newer materials.

Mossbauer effect: key to precision measurement

The fact that the gamma radiation from certain active atoms has a frequency–so regular and predictable that it provides an even better atomic "clock" than those produced by using the natural vibrations of gases (*PE*—Nov 4 '57, p 12)—is making it possible to test many of the advanced theories of physics, and promises to provide new standards of accuracy for industry.

The phenomenon is a rather new discovery, first noted by a German physicist, R. L. Mossbauer, now at California Institute of Technology.

He worked with iron 57, but more than a dozen isotopes have now been found to exhibit the effect, with zinc 57 being perhaps the most useful since its gamma ray resonance is of a very high order.

One of the first applications of the new discovery is in tests of the Einstein theory as applied to atomic radiation. If the theory is correct, there should be no detectable difference between the force of gravity and the force produced by acceleration outside a gravitational field, and a Doppler-like "red-shift" should occur when one group of radioactive atoms is accelerated with respect to another.

Normally, tremendous accelerations and speeds would be required to observe this phenomenon. But, with the great precision afforded by Mossbauer radiation, it has been possible to detect this shift merely by moving a radioactive source up and down a 70-ft column.

Precision thermometry shows trace-element effects

A study, originally aimed at determining fixed temperature points that could be used as benchmarks in place of the pressure-sensitive boiling points normally employed, has not only succeeded in that aim, but also provides a valuable method for investigating the effects of trace impurities on high-purity metals, E. H. McLaren of Canada's National Research Council told the Chemical Institute of Canada.

By taking advantage of precision resistance-thermometry techniques it has been possible to compare liquidus points of such metals as zinc, cadmium, lead, tin, and indium with an accuracy of ±0.0002 C, and determine liquidus points for alloys in most solutes with concentrations greater than 1ppm. Work on solidus points is now being initiated.

Tensile tests can be misleading

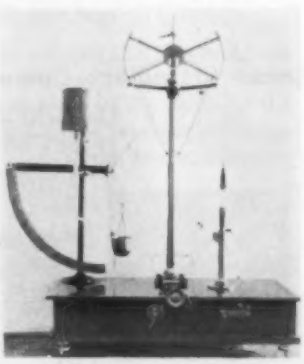
Short-term tensile and impact tests are not good indicators of damage by thermal fatigue, Soviet metallurgists V. Kostochkin and I. A. Oding warn. The reason: at the high rates of deformation used in these tests, microcracks do not have a chance to do their damage and affect the test results. They recommend use of the stress-rupture test, which they find more closely related to thermal fatigue and a better indicator of it.

briefs . . .

Metal-filled silicone rubber is being made available in experimental quantities by Connecticut Hard Rubber Co. The specific aim: to find out where this load-impregnated material might be used. CHR suggests radiation shielding and acoustic damping. The material can be supplied in sheet form and in forms suitable for molding and extrusion.

Depleted uranium is finding nonnuclear jobs–but it's still working for the atomic energy program. Hydromatics Inc used it to make a 500-lb ball for a special valve in the Enrico Fermi reactor. (Depleted uranium–metal from which the fissionable isotope U 235 has been removed–is piling up at AEC plants, and a major program is under way to find uses for it. This is one of the first.)–ARG

Testing a la 1920



FIBER STRENGTH was tested with this Rube Goldberg device 40 years ago. It looks primitive, but it measured torsional resistance as well as tensile and breaking strength, and it paved the way for today's precision instruments. Fabric Research Labs owns it, now has it on display.

FROM WASHINGTON . . .

Navy studies jet-propulsion for subs

The Navy is studying a revolutionary method of submarine propulsion known as scoop injection—or more commonly as "hole in the nose" system. Sea water taken in through the bow of a submarine is passed through condensers, then ejected through the sides of the sub to propel it through the water.

A report has been prepared by the David Taylor Model Basin, but the details are highly classified. Officials won't comment one way or the other on the report. The need to reduce noise in submarines is the big push behind the drive to find new methods of propulsion.

Nuclear-powered submarines are noisier than the conventionally powered boats and thus more vulnerable to detection by the enemy. The Navy has launched several noise-reduction programs for the atomic-powered submarines, but it is still a top priority project.

Camp Century, an arctic ice city, to test equipment

A major program to test equipment performance and living capabilities under ice will be launched this September. The Army has tunneled out a small town deep beneath the frozen icecap of Greenland, some 300 miles inland from Thule.

Called Camp Century, the ice city will be completely sealed off from the rest of the world. A group of engineers and scientists is scheduled to enter the camp this September and remain for an extended period, during which equipment and living conditions will be tested.

A nuclear power plant with a 100-year life has been installed to furnish power for the camp. All equipment and supplies have been installed to take care of man's needs.

Unconfirmed reports say that there are top-level plans to put a small colony in the camp if a nuclear war seemed imminent. It would be the Noah's Ark of survival. Life sealed in the ice city would escape radiation and fallout effects. After checking the atmosphere, the colony could emerge and perpetuate the human race, the story goes.

Raven to replace Corvus missile . . . maybe

Unofficial reports have it that the Navy will pump money saved from cancellation of the Corvus missile project into a new longer range system dubbed Raven. The Navy dropped its 100-mile plane-launched guided missile Corvus after spending $80 million on the project.

In all, the Corvus program was expected to cost around $450 million. Prime contractor was Temco, an electronics and missile company of Dallas. First contract on the Corvus was let Jan 17, 1957. Just this past March, the Navy made a $25 million extension of the Corvus contract.

Other systems show more promise—that is the official Navy reason for cancelling the Corvus contract. The missile had been flight-tested, but was still officially in the research, development and evaluation stage.

The Raven project is still in the feasibility-study stage, but it calls for a 500-mile-range air-launched missile. Guessing is that the program is tied to Navy's new Missilee: aircraft under design that is to be a slow-flying missile-launching platform. Aircraft bids are under study.

Gasket engineering

INTERNAL PRESSURE VS. EFFECTIVE SEALING

Internal pressure creates two forces which can cause leakage in a gasketed joint. Proper flange design and correct selection of gasket materials can overcome these forces.

E. M. SMOLEY,
Research Physicist
Armstrong Research and Development Center

The pressure of confined liquids or gases acts against a gasket in two ways, as shown in figure 1.

1. Hydrostatic end force. This is proportional to the internal pressure and

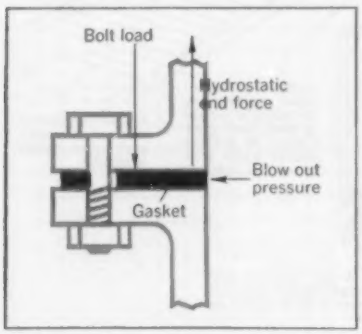


Figure 1. How internal pressure acts on a gasketed joint.

tends to move the flanges apart. As this occurs, the load on the gasket is reduced and leakage can result.

2. Blowout pressure. The sealed liquid or gas exerts direct pressure on

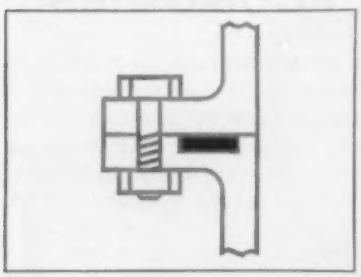


Figure 2. Flange design which confines gasket helps minimize blowout pressure.

the inside perimeter of the gasket. If this pressure is high enough, it will force the gasket out of the joint and leaks will occur.

These forces are usually associated with relatively high internal pressures. Studies at Armstrong Research and Development Center show, however, that pressures substantially less than 100 psi can cause leakage in some assemblies. (The Deflectometer shown in figure 3 is one tool used by Armstrong research engineers to measure flange deflection caused by internal pressure.)

Where internal pressures are involved, it is especially important to consider the joint as a unit. The flange design, the gasket material, and the temperature at the gasket line should all be considered in relation to each other.

The obvious first step is to be sure that flanges are sufficiently rigid to impose the required unit load on the gasket. The number of bolts, their size, their spacing, and their torque values are other factors related to flange loading which must be considered.

The second step is the evaluation of the gasket material to be used. High unit loads dictate the choice of a material that will not extrude or rupture under high pressures. This usually means a dense cellulose fiber or asbestos fiber material.

Several compositions suitable for service under high flange loads are available in the Armstrong Accopac line of beater-saturated gasket materials.

Where a compressible material such as cork-and-rubber is to be used, a flange design which confines the gasket,

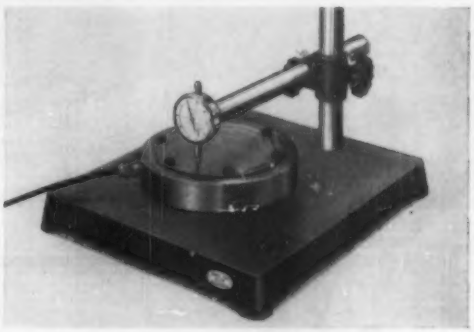


Figure 3. This Armstrong developed Deflectometer measures effect of 70 psi internal pressure in this stamped flange. Leak-producing deflections of .007" were detected at center point between bolts.

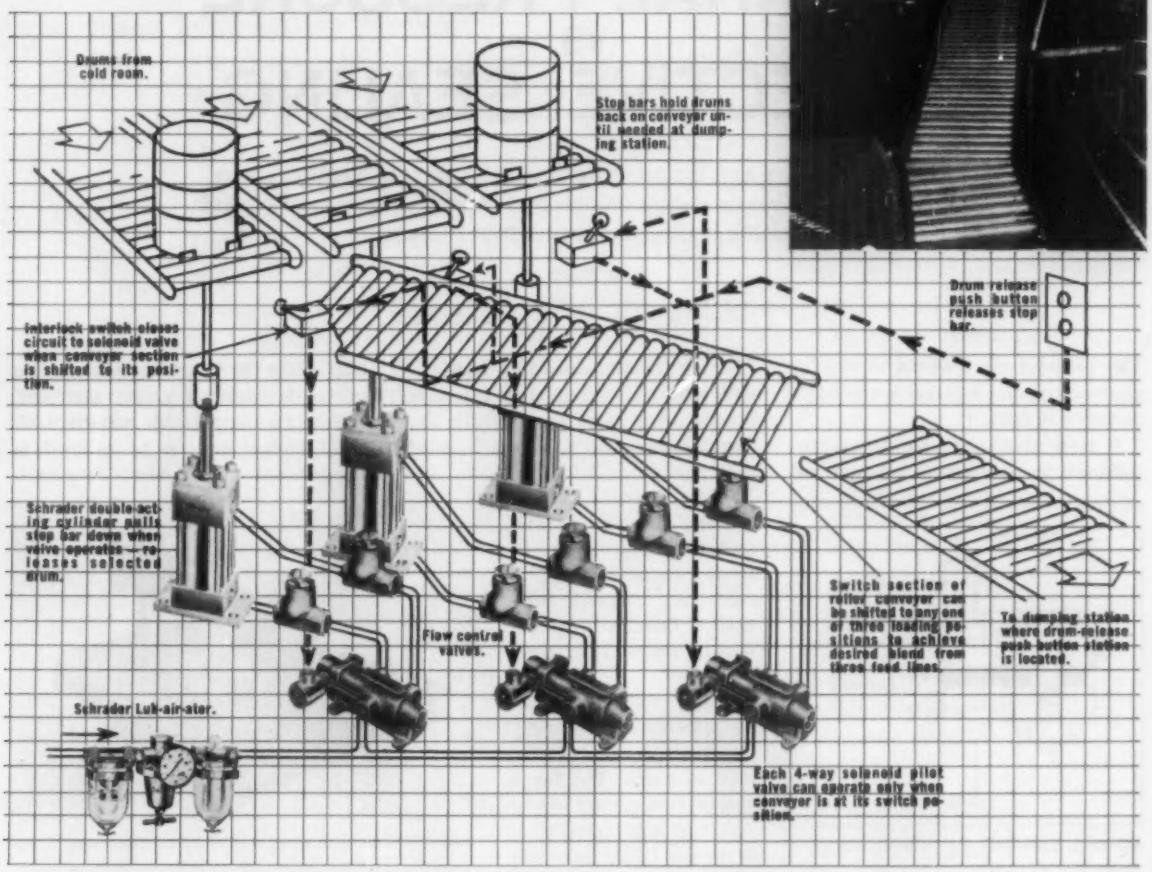
as in figure 2, will also help overcome blowout pressure.

A more complete discussion on the effect of internal pressure and other problems of gasket design, selection, and performance is included in the Armstrong Gasket Design Manual. Write today for your copy of this 32-page book. Address Armstrong Cork Company, Industrial Division, 7108 Irvin Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

1860–1960 Beginning our second century of progress

Processors automate even heavy work with air. In a complex frozen juice concentrate blending operation, Plymouth Citrus Products Cooperative, Plymouth, Fla., hooks up Schrader Air Products simply and economically to a gravity conveyor. Full 55-gal. barrels on feed sections roll down to stop bars and are selected in correct order and ratio for dumping. "The Schrader system performs well," says C. Byron Smith, plant manager. "We're handling 200 to 300 barrels a day on this selective conveyer, and could handle more."


Drums from cold room.
Stop bars hold drums back on conveyor until needed at dumping station.
Drum release push button releases stop bar.
Interlock switch closes circuit to solenoid valve when conveyor section is shifted to its position.
Schrader double-acting cylinder pulls stop bar down when valve operates – releases selected drum.
Flow control valves.
Switch section of roller conveyor can be shifted to any one of three loading positions to achieve desired blend from three feed lines.
To dumping station where drum-release push-button station is located.
Schrader Luk-air-ator.
Each 4-way solenoid pilot valve can operate only when conveyor is at its switch position.

PROCESSOR AUTOMATES BACK-BREAKING CHORE WITH SCHRADER AIR PRODUCTS . . . GAINS SPEED, EFFICIENCY, BIG ECONOMIES

Solve difficult problems of handling, conveying and sorting, just like this company . . . with air! Versatile Schrader Air Products take punishing environments in stride, even corrosive atmospheres . . . Work together like magic on American production systems of many different kinds in hundreds of industries.

You already have air. Add Schrader Air Products to push, pull, hold, position, move work repetitively . . . cure headaches of weight, assembly, production maintenance . . . perform tirelessly and with precision. Speedy yet safe Schrader takes the drudge out of work, adopts to special needs, saves time, money and effort.

Select from the full Schrader lines to plan your automation of machines. Your Schrader distributor can help you pinpoint what you need. For more data write:

Schrader®
a division of SCOVILL

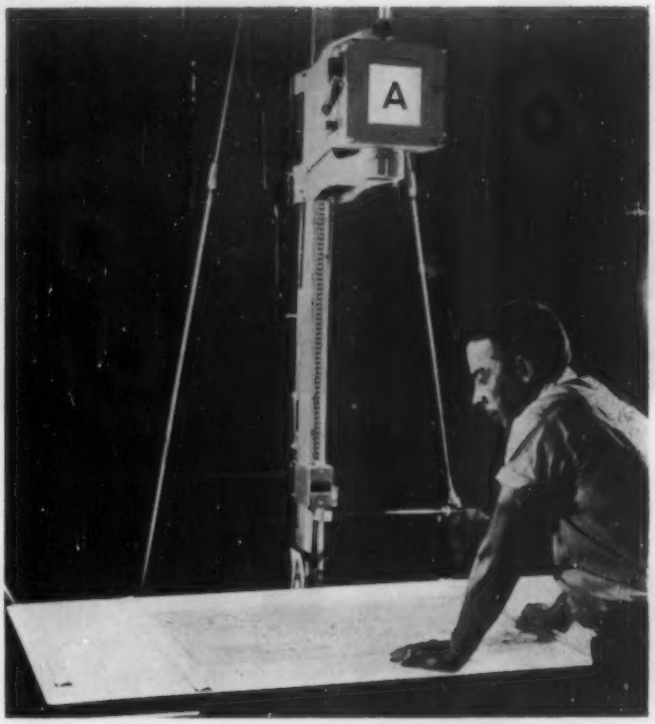
A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
477 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

THE ENGINEERING WEEK

Aperture Cards for Space-age Drawings

- SAVE TIME
- CUT COST
- REDUCE SPACE
- SPEED RETRIEVAL



1 **MICROFILM CAMERA** used at Redstone Arsenal photographs all engineering documents originating within ARGMA as well as original drawings submitted on paper by small contractors. Officials estimate camera handles more than 30,000 drawings a month.

HUNTSVILLE, ALA—The use of microfilm instead of blueprints for recording engineering data and drawings is saving the Army's Rocket Guided Missile Agency (ARGMA) some $60,000 a month here at Redstone Arsenal.

While the Air Force has also put microfilm and aperture cards to work in engineering communication (*PE—Mar 14 '60, p 15*), Redstone has many techniques and much equipment that is unique, having evolved from ARGMA's specific needs. The agency has been using microfilm for the past three years. Its engineering documents section has an active file of over 850,000 drawings and its historic file contains 1½ million drawings and documents—all on microfilm mounted in aperture cards.

2 **FILMSORT SEMIAUTOMATIC MOUNTER** is able to verify a previously punched EAM aperture card and mount the corresponding microfilm fast enough for one operator to process 3000 daily.

ARGMA reports it is equipped for instant, complete mechanical retrieval of any of its 1½ million drawings. In addition, it can print out in virtually any form desired—paper-to-paper, card-to-card, card-to-paper and paper-to-card. Strategic positioning of viewers and reader-printers throughout the Documentation Services Unit and the engineering section permit as many persons as necessary to view enlarged microfilm drawings, and within seconds, provides them with a paper copy for future reference.

ARGMA began its unitized microfilm program in 1957 with two microfilm cameras and several electrical accounting machines (EAM). The program has since progressed into a highly integrated operation with prime suppliers and contractors required to submit their engineering data—already filmed and mounted in aperture cards—to headquarters here and also to selected depots.

Hard copy is still received and processed from small contractors whose work load doesn't justify installation of filming, card-punching and mount-

3 **ELECTRICAL ACCOUNTING MACHINES,** keyed to aperture cards, is the backbone of the system. Here in Redstone's EAM Section, a group of cards can be filed in any desired sequence and any one card can be retrieved from the file in a matter of minutes. Next step is copying: there are three basic methods . . .

5 **CARD-TO-PAPER COPYING**—here the low-cost Filmac 200 reader-printer extensively scans any microfilmed drawings; it can produce an 18 x 24-in. paper copy within 10 sec. It is the workhorse of the engineering dept. A variation of the same method . . .

4 **CARD-TO-CARD COPYING**—the Filmsort card-to-card printer is especially adapted to Redstone's needs. It is geared to print duplicate cards for mass distribution at a rate up to 600 cards per hr. All requests for reproductions are answered by using duplicates reproduced from these machines, keeping master file up to date

6 **PAPER-TO-PAPER COPYING**—which is still possible at Redstone. With the above equipment, paper duplicates can be reproduced quickly for necessary distribution to any one of a dozen points.

ing equipment. In addition, ARGMA microfilms all engineering drawings originating at the agency.

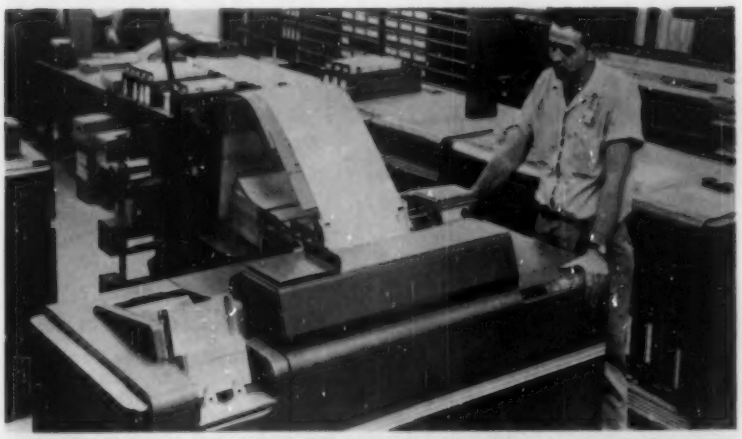
One big advantage of the unitized microfilm system is that the EAM aperture card, once verified, contains a forever-accurate engineering drawing record that can be easily retrieved and reproduced. Another advantage is space-saving; it is now possible to store 100,000 film drawings in only 4 sq ft of floor space. And ARGMA has reduced its clerical filing personnel by more than 40% since mechanizing.

In addition to the EAM microfilm aperture card, ARGMA has formulated and put into its mechanized system other EAM punch-card projects that tie in with, and control, the engineering-drawing operation. These projects are designed to be switched from a basic machine operation to a high-speed computer operation with minimum programing for maintaining accurate engineering records.

One of these projects is called the "generation breakdown." This system features a punch-card deck, is simple in design and is furnished by the contractors along with the engineering drawing microfilm card. From this one deck of cards, ARGMA can prepare mechanically (1) a complete generation breakdown to include nuts, bolts, screws for any major item of any given missile or rocket system; (2) engineering parts lists; (3) engineering drawing lists; (4) engineering specification lists; (5) parts usage lists; (6) lists of drawings by number.

An alphabetical item-numbering system (not to exceed 6 positions) has

7 **AUTOMATIC CONTINUOUS ELECTROSTATIC PRINTER** which prints the microfilmed image from aperture cards onto either plain bond paper or reproducible paper at a rate of 20 ft per min. Each copy is individually cut automatically as it leaves the machine.



8 **ADVANCED BUSINESS-MACHINE EQUIPMENT** permits Redstone to print out from aperture cards any desired tabulation of information in the prescribed order and, if the cards used are destined for removal and subsequent destruction, it will even write its own disposal information.

been devised for the "generation breakdown." Result: approximately 476,000 components for any one major assembly can be mechanically controlled with the possibility of making about 2000 changes and additions between any two line components. This system is said to be the most efficient means of such mechanical control.

Another EAM punch-card project is the master index of ARGMA packaging data. This index is prepared and published in both ordnance part number sequence and federal stock number sequence in EAM punch-card decks and in bound-book form. It contains the item, name, packaging specifications, cleaning method, drying method, preservation type, protective method, unit, intermediate and exterior quantity, weight and cube plus the ordnance part number and federal stock number. By development of approximately 50 packaging data standards, this index replaced the requirement for individual packaging data sheets for approximately 75% of the repair-part items. ■

Space Communications System by 1970; New Laws Required

NEW YORK—Earth-space-earth communication "will be technically and economically feasible by 1970," Dr Edwin G. Schneider, vice president of Sylvania Electric Products Inc, told the Federal Communications Commission. Backing this remark, Frederick R. Kappel, president of American Telephone and Telegraph Co informed a group at the Univ of California that "perhaps 500 to 1000 channels from a single satellite system" are possible, and "hopefully, a great many more than that."

Space communications relies on orbiting a "stationary" satellite some 22,000 miles above the equator. It would travel in the direction of the earth's rotation and at the same speed. Besides television, telephone and telegraph messages, such information as high-speed facsimile and high-speed digital data could be sent.

Mr Kappel termed "Project Echo," which is currently sponsored by NASA, a key step in space-communications research. The aim of the project is to get a 100-ft-dia balloon satellite into orbit and then "bounce" voice signals off it between stations in New Jersey and California. Immediate aims are:

- To determine whether speech can be transmitted.
- To gather data on radio waves.
- To test communication-system components.
- To check the balloon itself—whether it will work as anticipated; keep its shape; and withstand the effect of meteorites.

Dr Schneider urged the FCC to reserve a substantial number of frequency bands between 890 and 10,000 mc for future commercial and military space-communications systems. He pointed out that many problems and legal questions exist involving rights and liabilities in placing a satellite in space, and overlapping signals beyond national boundaries. Thus Dr Schneider recommended that the US take a strong stand at the Extraordinary Administrative Radio Conference of the International Telecommunications Union scheduled for 1963, in favor of reserving enough frequencies

for earth-space-earth common-carrier and private communications to permit several broad band channels for transmission of such information as television, high-speed facsimile and high-speed digital data; and to permit the ultimate assignment of more than 1000 voice channels, some of which might alternately be assigned for teletype messages. ■

Lag in Standards Hurts Electronic Design

BOULDER, COLO—Standards to meet today's electronic equipment needs are still 5 to 10 years away—and there's no telling what our needs will be by that time. This is one discouraging conclusion from a series of meetings held by the National Bureau of Standards with industry representatives here.

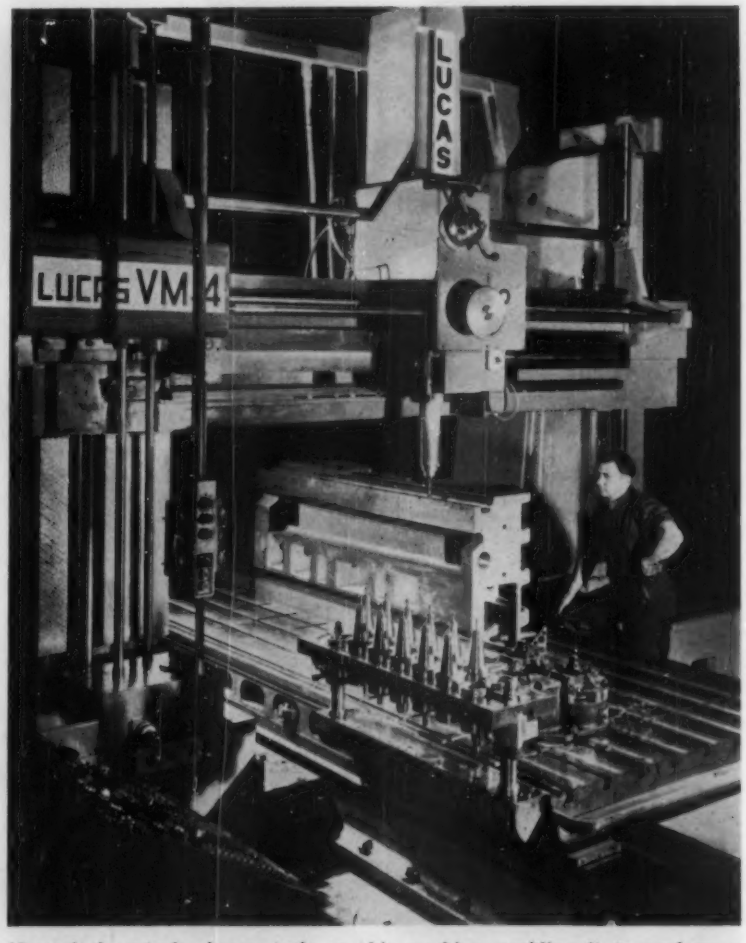
Klystron tubes for generating high-power signals for radar detection systems are over-designed just to be sure they are powerful enough to do the job, the NBS was told. This is necessary because there is no way to measure their peak microwave power precisely.

A few years ago, the performance of an operating radar set could be determined by two or three measurements, it was said. But to measure the performance of today's radars requires testing many new and complex items of equipment—and quite often radar is considered to have failed when the fault was within the test instruments themselves.

One of the problems cited is that measurements of microwave power, made on different days by the same equipment, will disagree by 50%. Yet radar systems are often operated close to breakdown and it is necessary to hold power within 5%, or even less, if a radar system is to be kept operating.

To correct the situation, the NBS suggested that more money for standards research would help. But money alone won't do the trick. It won't train scientists faster, though it may train more of them. In the interim, NBS suggests establishing at least an informal priority system for development—and moderation on demands for accuracy, avoiding the tendency to specify "impossible" accuracies "just to play it safe." ■

Chooses Correct Tool by The Numbers



Numerical controls change tools on this machine, enabling it to perform a variety of operations on the same part, to tolerances of 0.0002 in. First machine designed and built by Lucas Machine Div of New Britain Machine Co, the Versa-tronic has a bank that holds 14 tools. With mounting room for six such banks, total capacity is 84 tools. Machine tool is designed to automate small-lot production.

Radar May Free Oil Reserves

NORWOOD, MASS—Deep-penetration radar beams may soon help unlock trapped oil reserves jellied in rock many thousand feet beneath the earth's surface. Petroleum engineers estimate that these reserves, inaccessible by present extraction methods, comprise about seven times the amount of oil as is now considered economically recoverable. The engineers believe the oil can be brought to the surface if temperature is raised 20 F in a 2-ft area around the well bore.

One system for raising bore temperature, now under development at Raytheon's Commercial Apparatus and Systems Div here, employs special electronic generators of very high frequency in the microwave band. These generators, producing 5000 to 10,000 watts, will be packaged in a 6-in.-dia capsule. They are similar in design to dielectric heaters.

This first capsule is designed to fit inside a low-producing well in northwestern Montana, where initial testing of the device will take place. The well is 3500 ft deep. Subsequent tests will be conducted in other wells of

different depth and formation.

The microwave device is being developed in a cooperative program with Petro-Electronics Corp of Denver. Engineers of the Denver company are contributing geological and oil-production experience. ■

Are Annual Car-model Changes Going Out?

DETROIT—The betting here is that the annual changeover in automotive styling is on the way out, and there'll be a general toning-down of design extremes beginning with the 1961 models.

No one expects the end to come suddenly but at least some models—most likely the compacts, which should double their sales next year—will remain unchanged. An example of the "no-nonsense" design for 1961 will be pared-down wrap-around windshields to eliminate "dog legs" which make it harder to get in and out of the front seat. Also a finis to fins as well as a soft touch to car-body sculpture. Restrained design is expected to give better utilization of sheetmetal, reduce over-all width, and often increase usable space.

ENGINEERING TO DICTATE REDESIGN

If the forecast on the passing of annual styling change is correct, new features in design and construction will have to come primarily from engineering, as functional changes will have to be introduced more often to encourage trade-ins. Result: a larger emphasis on engineering research and development, use of new metals and production processes, closer attention to passenger comfort, human engineering, safety and reliability, economy.

Forerunners of this trend made their appearance in the 1960 models with inclined engines, new engine locations, air cooling, new treatment of transmissions, wider treads, the spread of unitized body design. In 1961 the trend will become established, and is expected to spread through all the automobile lines.

For instance, increasing attention is being paid to durability of upholstery fabrics, prevention of sheetmetal corrosion, more durable finishes, both in paint and chromium plating. At least one automobile company will offer aluminum bumpers—chromium-plated so as to have the same appearance as the steel bumpers they replace.

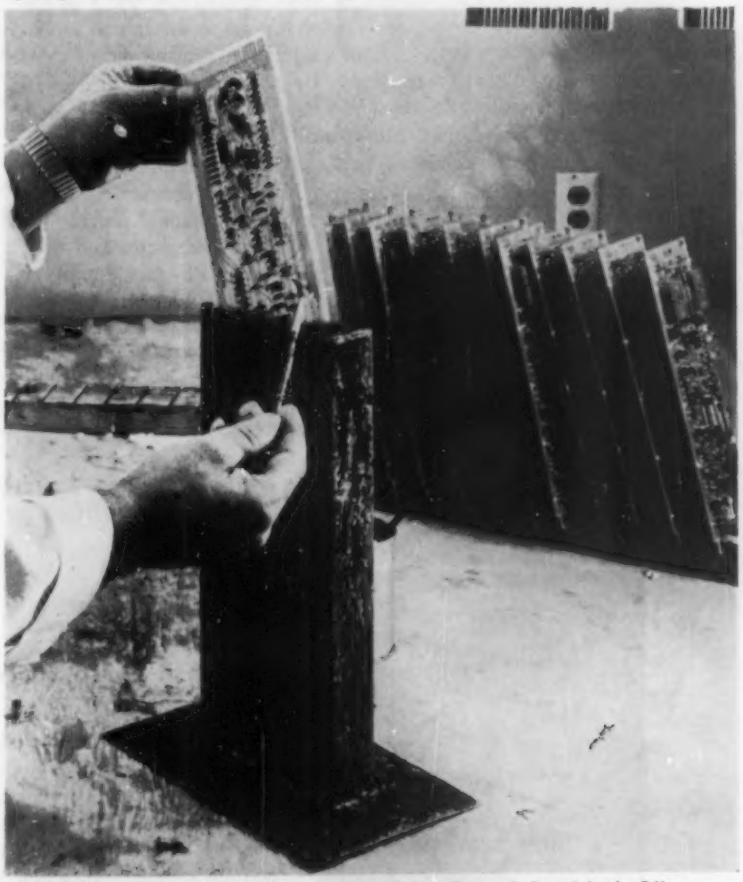
Whatever the automobile companies say, they have long been aware of the coming change, they have long known that the time was coming when they'd have to offer mechanical innovations instead of changed appearance. This is the reason behind the industry's insistence on machining lines designed with greater flexibility, with standardized bases and transfer equipment and changeable work heads for year-after-year use.

Such a building-block concept has already been largely approved, and many manufacturers are applying standardization well beyond the industry approved minimum.

One large manufacturer of special machines describes a new machine soon to be delivered to an auto company as "the first in a new line of . . . standardized designs" built so as to "permit wing-base units to be spaced around the (central) column at any desired position."

—Felix Giordano

Epoxy Guards Printed Circuits



Coating and potting techniques developed by General Precision's Librascope Div help protect printed circuit boards of digital computers from humidity, contamination, shock and vibration. Coating process deposits a layer of epoxy on the assembly by dipping or spraying. After leaving the coating section, circuit boards are baked at 150 F to harden the thermosetting epoxy. Heat must be adequate to cure the plastic without damaging performance of the delicate electronic components. Masking tape is used to keep contacts and terminals free from the plastic coating in the oven. The potting operation protects assemblies with boards joined in parallel to form an open-sided box construction with electronic components inside and outside the box. Epoxy is also used during the followup potting operation with special fillers added to give maximum heat dissipation.

POINTS OF VIEW

THE QUESTION:

When Does Automation

W E Walton
Vice-president, Engineering
DeWalt Div
American Machine & Foundry Co

"When it adds complexity and cost . . .

without freeing the user from significant inconvenience or physical effort. A garage-door opener is an example of useful automation, but a motor-driven depth-of-cut adjustment on a radial arm saw is difficult to justify. Automation should free the user from a significant demand on his time. For example, an automatic washer saves considerably more than does an electric can opener. Such devices should also control a process with more precision than can be accomplished manually. One of the most common automatic controls for consumer goods is the thermostat; it controls ovens, electric skillets and furnaces with far greater accuracy than the consumer could otherwise obtain. And automation should provide the user with a greater measure of safety. For example, automatic over-temperature controls on home heating units, automatic circuit breakers, and photocell control of yard lights provide safety. (Perhaps even the electric can opener would finally qualify in this respect.)

"In all the successful applications of automation to consumer products now on the market, you will find at least one of these benefits. When automation does not supply at least one of these, it is merely automation for its own sake."

Claire Ely
Vice-president, Marketing
The Maytag Co

"When it complicates the use . . .

or confuses the user instead of simplifying the task it is designed for. It goes too far when its sole purpose is to further artificial obsolescence. It's my observation that the two tend to go hand in hand.

"In the home-laundry appliance industry, automation has been developed to a considerable degree in recent years. Much of it has been good, some not so good. To the good, I believe, are those developments which perform automatically a function that the homemaker formerly had to do manually and those which eliminate the need for knowledge or decisions on her part. May I add that they should perform these functions without materially increasing the service problems. Automation goes too far, I think, when it creates Cape Canaveral complexities of controls, adds to service problems or when, of course, a change does not involve a true product improvement."

in Consumer Products Go Too Far?

"Any time the resulting device becomes so complex . . .

that it is not reliable. I'm sure we've all had the personal experience of riding in an automobile that is ostensibly fully automatic. But if the hydraulic system goes out (it's always on a rainy day), you may find yourself in a $5000 convertible with the top at half mast, the windows half down and perhaps the brakes not working. In a somewhat facetious vein, this is a good example of what we would call carrying automation too far. A man would probably rather put down his top by hand than risk failure of an automatic function at a particularly critical time.

"As a company policy, therefore, we have always taken the view, as our president says, that a good company and the resulting product rest on three foundations: Good engineering, good production and good sales and service. We have often stumbled upon extremely good ideas in the engineering phase only to find that it would be very difficult to manufacture the product, and perhaps even more difficult to service it once in use. For this reason, we have always selected for production and sale those products which we are certain can be produced to acceptable standards, and which will require a minimum of service once in use.

"Our goal is to make everything truly automatic—to the degree that our individual lives and over-all standard of living can be made better and more comfortable by so doing. However, we always keep reliability in mind. For example, it's possible to design a system that could hold a room temperature to a fraction of a degree, but it would probably require virtual laboratory conditions to keep it operative. Instead we prefer a system that maintains a reasonably comfortable temperature with no trouble. In other words, something that works reasonably well with high reliability is, in practically every instance, preferable over something that works extremely well, but has low reliability. I think we as a nation could do well to keep this in mind in manufacturing any consumer product."

J F Ray
Vice-president, Sales
General Controls Co
Glendale, Calif

William M Day
Vice-president
Landers, Frary & Clark

"Each time that some company automates . . .

a product to replace a simple, easy, or infrequent manual operation, there are many practical-minded people who sing out 'You've gone too far.' However, there are many reasons which motivate people to buy automatic products and quite a few of them do not involve being practical.

"Since our business is to develop and build products which the consumer wants, we can only conclude that when a product is developed that the public won't buy, even if only for 'pride of ownership,' then we have gone too far. Of course, this philosophy is from the standpoint of a manufacturer and does not consider the viewpoint of the man who remembers fondly how grandmother used to make a wonderful meal, 'and she did it all with her own lovely hands'."

United States Testing Company offers a

NEW CALIBRATION SERVICE

for

* Electrical
* Electronic
* Temperature Instrumentation

You can meet government accuracy requirements... and get fast, one-stop calibration service in our Calibration Laboratory. Here's what you get:

* **Calibration Certificate** – guarantees that test equipment has been compared to standards periodically certified in terms of National Bureau of Standards References.
* **Calibration Data Sheet** – a log of readings at various check points on the instrument scale.
* **Seal**–attached to equipment...shows date of Certified Test of reference standard.
* **Tag**–attached to equipment...shows date of last test and due date of next test.

Ask about our Contract Calibration Service where we keep calibration records and remind you of due dates. If you are in the metropolitan area, our In-Plant Calibration Service can prevent a production stoppage. Why not write or phone for a calibration service to meet your needs.

12

Send for free bulletin describing our services

The World's Most Diversified Independent Laboratory

United States Testing Co., Inc.
1415 Park Avenue, Hoboken, N. J.

Branch Laboratories | BOSTON • BROWNSVILLE • DALLAS • DENVER • LOS ANGELES MEMPHIS • NEW YORK • PHILADELPHIA • TULSA

READER TO EDITOR

Reliability Report

To the Editor:

I have received your May 16 special report "A Manual of Reliability." An excellent job and well put together. You should have attended the annual meeting of the American Society for Quality Control in San Francisco and heard Rear Admiral Paul D. Stroop deliver his paper, "Quality Control and the Reliability of Guided Missiles." This was a stinging challenge in an attempt to wake American industry out of its lethergy during these days of great consequences. It was a 40-minute presentation of a 17-page paper. He read every word to some 2000 so you could hear a pin drop.

—Kenneth K Knopf
Hillsborough, Calif

A Plea For Small Drawings

To the Editor:

Are big drawings necessary? Not always. In fact, there are reasons for believing that much of our design work covers oversize sheets of paper, conferring more hindrance than help upon the users.

Although a good large-scale layout or assembly is often helpful, a word should be spoken for the little drawing, and for the ways in which it can save time and trouble. Speaking mainly about layouts and assemblies, drawings tend to be large because: (a) We want to show everything on one sheet (b) We like large-scale views (c) We aren't sure how many views we will need before we finish and (d) We want to leave room for additions, notes, miscellaneous. This is all commendable. In addition we are probably subject to a certain amount of claustrophobia and ego frustration. We want to think and do big, so we draw big; and inflation creeps into our design office as it does into our expanding economy.

In the first place, "this drawing will give 'em everything" philosophy can lead to trouble. Take the layout which essays to give all the information the detailers, checkers, and other designers will ever need. Unless the subject is simple, it can easily lead to scores of overlapping lines. More clarity is lost than information gained. A complex mechanism, the heart of which is drawn faithfully and completely, and changed and rechanged a few times, ends up with dark-gray regions due to the erasures and smudges. It looks terrible and is hard to use, but at this stage who will undertake to redraw it?

At the opposite extreme is a simple drawing consisting of a relatively few lines, with great blank expanses between, which has to be spread out on a large table or board to read or scale. Probably the cure for this particular excess is to give the draftsman a smaller board. It isn't primarily the cost of the paper, although this can be an item. Handling unnecessarily large tracings or prints, rolling up and unrolling, or folding and unfolding, or inserting in and extracting from wide flat drawers, is cumbersome. Other things

being equal, smaller sheets can be transported, worked with, shown, reproduced, and filed more easily than large ones.

Returning to the prime offender, the overloaded drawing, the following solution presents itself: Make a conservative-size main drawing, showing outlines, arrangement, and locations. Supplement this with supporting drawings to elaborate upon details or specific aspects. These sublayouts can be constructed to the particular scale—and size—which is most advantageous for them. They may be sections, cutaways, or schematics, whichever best clarifies the particular visual problem. In other words, different drawings may accomplish different objectives. In a gearbox, for instance, it is more convenient to make a gear analysis from a separate sketch showing pitch circles, center distances, coordinates, rotations and speeds, and to make an interference and clearance study from a drawing which emphasizes axial relationships of gears, hubs, mounting plates and housing. Several views on one drawing are all right, of course, but moderation should be exercised.

Revisions can be made on the drawing that is most pertinent. Even if several or all layouts are affected by the change, the damage is less when the congestion is less, and worn-through tracings and unreadable prints are avoided. Prints need be made of only the drawing or subdrawing in a given case. Not every user wants to be encumbered with all the information. The eye and the mind cannot take in the forest and the trees at the same time. One must consider the over-all picture or else concentrate on a specific area. It is safe to assume that in general there is an optimum amount of pencil work that a drawing can contain without straining eyes and brain in one extreme, or neck muscles in the other.

Let's not do away with big drawings, but let's not get carried away. Sometimes the "D" (for David) size proves capable of overcoming the "G" (for Goliath) size.

—Morton P Matthew
Norwalk, Conn

COMING EVENTS

AUGUST

1-4 . . . . Society of Photographic Instrumentation Engineers, 5th Annual Technical Symposium, Ambassador Hotel, Los Angeles

8-12 . . . . American Institute of Electrical Engineers, Pacific General Meeting, Cortez Hotel, San Diego, Calif

14-17 . . . . American Society of Mechanical Engineers and AIChE, Heat Transfer Conference and Exhibit, Statler Hilton Hotel, Buffalo, NY

23-26 . . . . Western Electronics Conference and Exhibit, Los Angeles Calif

28-Sept 1 . . . . American Society of Mechanical Engineers, International Heat Transfer Conference, University of Colorado, Boulder, Colo

ANCHOR®...THE PLEDGE OF PERFORMANCE

IN HYDRAULIC TRANSMISSION LINES.

Failure in a fluid power transmission line is usually costly, with expensive equipment down, production delays and idle manpower until repairs can be made.

To hold such breakdowns to a minimum, Anchor has not only established rigid quality standards to which all Anchor Hydraulic Hose Assemblies must conform, but makes frequent tests and inspections of materials and workmanship to ensure conformity to these high standards.

Because of this, the Anchor emblem on any piece of hydraulic equipment is a real "pledge of performance" and service.

Andy Anchor says:

Send for catalog describing the complete Anchor line.

ANCHOR HOSE ASSEMBLIES with ANCHOR Pressed-On Couplings are available for high, medium and low pressure service with maximum working pressures ranging from 12,500 PSI for 3/16" I.D. 6 Ply Super Spiral Hose to 100 PSI for 2" I.D. Spiral Wire Suction Hose.

ANCHOR REUSABLE COUPLINGS — Regular or Clamp Type, are available for emergency repair and year-to-year superior performance for high, medium and low pressure service ranging from 5000 PSI for 1/4" I.D. 2-Wire Braid Hose to 100 PSI for 2" I.D. Spiral Wire Suction Hose.

ANCHOR 4-BOLT SPLIT-FLANGE "O" RING HEAD COUPLINGS are available in a wide range of sizes for high, medium and lower pressure applications.

ANCHOR ADAPTER UNIONS, PIPE FITTINGS, SAE BOSS TYPE FITTINGS A complete line of Pipe and Tube Fittings, Adapter Unions and SAE Boss Type Fittings are offered in a variety of styles and sizes to satisfy the requirements of any installation.

ANCHOR COUPLING CO. INC.

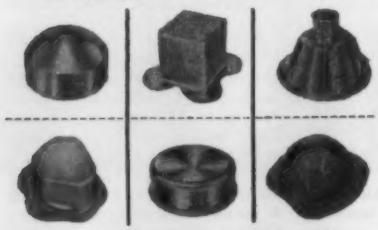
354 North Fourth Street, Libertyville, Illinois

Branch Plants: Dallas, Tex., Plymouth, Mich.

KAUPP
PRECISION-FORMED
METAL
COMPONENTS

Hydroforming, Deep Drawing and Spinning

You can depend on KAUPP for complete service from design to delivery on precision-made metal parts and sub-assemblies. Ultra modern metal working facilities, plus wide experience on military and commercial requirements are available to solve your problems. Send drawings for quotations or phone for new illustrated bulletins!



Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

C. B. KAUPP & SONS

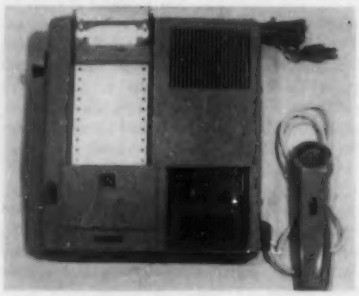
Metal Craftsmen since 1924

NEWARK WAY, MAPLEWOOD, N. J.
Telephone: SOuth Orange 3-2490

FOR YOUR INFORMATION (personal)

Phone recorders at $100

A recorder for telephone conversations that will be priced at only $100 is being readied for commercial introduction by Nippon Victor of Tokyo. It uses a paper roll holding two hours' worth of conversation, comes complete with eraser, ear horn, telephone pick-up, printer, and extension speaker. The paper takes pencil markings, too, so notes can be written on it. The unit is transistorized, weighs 15 lb.



Plastic shells promise safer shooting

Disappearing cartridge cases and high-strength linear polyethylene shells are the latest innovations for the discriminating hunter. The "disappearing" (combustible) cases are not commercial yet—are still being evaluated by military agencies. But the plastic cases are already being offered by Remington Arms for all-weather use. Remington says they won't swell in rain, snow or sleet, will not scuff or mar, and will maintain ballistic and dimensional stability.

An interesting sidelight is the choice of material. Says Remington: As ordinarily fabricated, high-density linear polyethylene would not be strong enough for a shotgun shell body. However, a new biaxial orientation process increases its strength "up to four or five times."

Warning to the novice: The bodies of the new shells are translucent so that shooters can see the interior components. The time-worn alibi, "absolutely no shot in that shell" won't work now.

Vacuum your ashes, sir?

A vacuum trash-receiver that doubles as an ashtray and operates from a car's vacuum system will soon be marketed by Ford and Mercury dealers. It connects to the intake manifold of the car, and is so designed that the vacuum is applied only when the tray drawer is fully opened. Thus, it can serve as ashtray as well as disposer. Price of the unit, installed will be about $13. The Delman Co of Detroit is the manufacturer.

Tire-cord battles highlight new materials

A 20-year-old war takes on new interest—and new engineering importance—as new materials enter the fray. It's a battle among fibers and fabrics used for tire cord, and also for hydraulic reinforcing diaphragms, V-belts, and conveyor belts.

Before World War II, there was only one reinforcing fiber: cotton. Then came rayon and, by 1950, it was undisputed king. That year, of 462 million pounds of tire cord and fabric used, 297 were rayon, and only 165 cotton. But a new material, nylon, was coming along. And by 1959, nylon consumption was 121 million out of a total of 412. Cotton was down to 4.

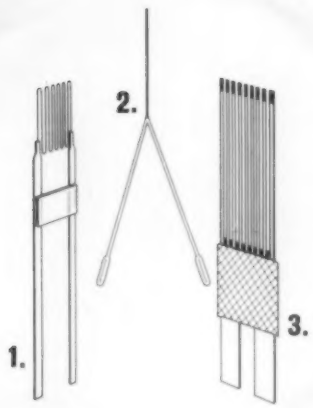
Now, a raft of new materials has altered the picture. Polyester fibers, polyvinyl alcohol and glass are already under test. Wire reinforcement is in limited use (PE—June 29 '59, p. 8). There are battles within battles as well. Nylon 6 and nylon 66 are jockeying for position. By the end of 1961, it is estimated, total capacity for producing nylon tire cord will be about 300 million lb—200 million for nylon 66, and 100 million for nylon 6.

What's next? The entire picture could change overnight if new tire materials, having different reinforcement requirements and adhesion properties, come along. Perhaps new elastomers will be developed that do not need reinforcement at all. Meanwhile, the "battle" is bringing lower prices, and it promises much-improved products. —ARG

CIRCLE 24 ON READER SERVICE CARD

CIRCLE 25 ON READER SERVICE CARD→

New BLH Strain Gages simplify strain measurement at elevated temperatures



1. **HT Free-Filament Strain Gages*** meet the need for gages that are easy to handle and apply . . . are reliable and drift free at elevated temperatures. They quickly and accurately measure strain on any test surface. All five standard sizes have 2-in. flat leads swaged to the flat grids and free of any spot welds or solder joints. Proper alloy selection assures reliable performance even at temperatures well above 1000°F. Standard grid resistances from 120 to 2000 ohms. Write for Data Sheet 4330.

2. **HTM Mono-Filament Strain Gages** open new areas of strain measurement. Unique design virtually eliminates transverse sensitivity. Subminiature size (less than 0.012 in. dia.) permits application in crevices, fillets, corners, grooves, keyways, bolts and gear teeth. Ideal for high temperature static or dynamic testing. Gage elements are preinsulated, eliminating the need for a precoat and simplifying application. Standard resistances of 60, 120 or 240 ohms. HTMI Strain Inserts also available with ceramic insulators at lead ends for gaging in drilled holes in studs, bolts and similar applications. Write for Data Sheet 4331.

3. **FNO and FAO Free-Handling Foil Gages** are specially designed to simplify their application wherever high-temperature strain measurement is required. The major advantage to users is that most of the grid is exposed, with only the main tabs and filament junction tabs supported by a specially prepared glass tape. The tape removes easily during installation. Conventional temperature limits for static and dynamic strain measurement apply to the Nichrome V** and Advance** alloys used. Supplied in removable vinyl envelopes to protect grids. Write for latest information.

TURN PAGE FOR MORE STRAIN GAGE DATA

*Manufactured and sold under exclusive license of High Temperature Instruments Corp., Philadelphia, Pa.
**TM Driver-Harris Co.

STRAIN GAGE HEADQUARTERS, U.S.A.

World's most complete line backed by on-the-spot availability and service

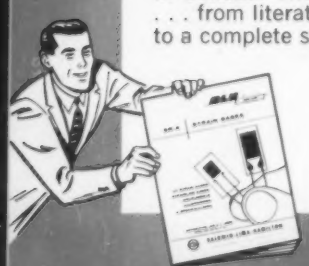
Whatever your strain gage needs—wire, etched foil, photoelastic, special purpose—BLH experience, quality and nearby service and availability give you more for your money.

Over 350 types and designs of strain gages are readily available from BLH as standard or semi-standard items. These gages cover 95% of known applications. And BLH is on top of every major breakthrough in strain gage design . . . now leads the industry in the areas of high temperature strain measurement, self-temperature compensated gages, as well as the most advanced line of SR-4® Bonded Strain Gages.

Tremendous strides are currently being made in the manufacture and application of foil gages by BLH research and engineering groups. Particularly in the areas of miniaturization and elevated temperature strain measurement, it will pay you to stay abreast of latest BLH advances.

An intensive and still growing line of accessories is also part of the service you can expect and get from BLH. Instruments, bonding cements, lead wires, solders, waterproofers, solvents and various equipment and kits are included.

Unmatched availability and service is another big plus you get when you look to BLH as strain gage headquarters. Fifteen strategically located sales-engineering representatives carry a full line of BLH Strain Gages and accessories in stock for fast delivery. These qualified specialists maintain 41 sales offices throughout the United States and in Canada. They are ready to meet your needs . . . from literature or a single package of gages to a complete strain measurement system.



For the name of your nearest BLH representative, write for a copy of this new full-line catalog.

Efficient, complete stockrooms like this one enable BLH representatives to quickly meet your strain gage requirements.

Factory trained technicians and modern equipment in BLH representatives' service departments provide speedy repair and assembly service.

Mobile demonstration unit is one of the modern vehicles used by BLH representatives to serve customers.

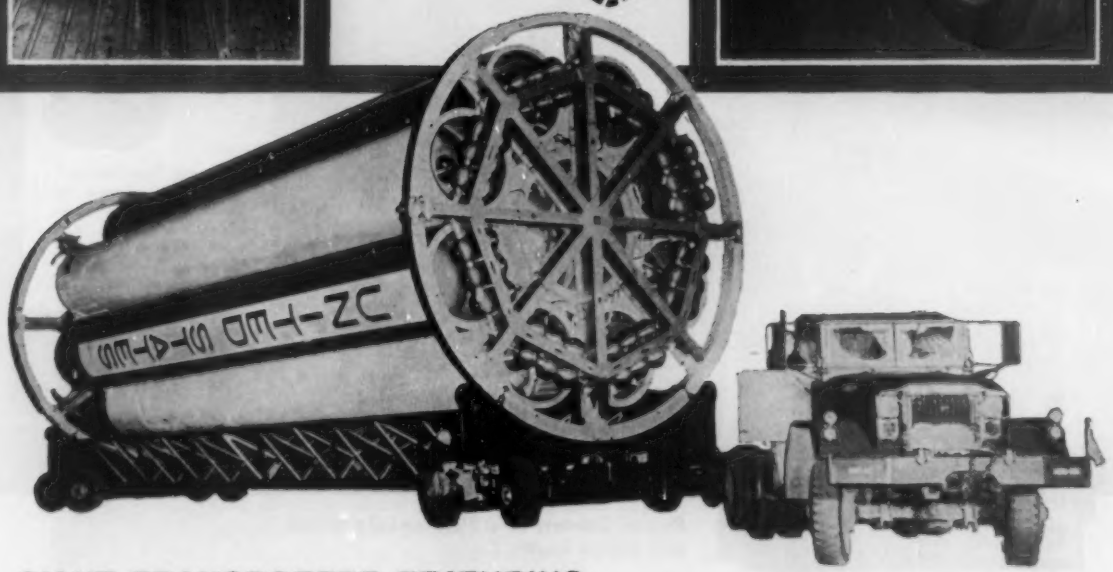
BLH sales-engineering representatives are located throughout the nation and in Canada to provide fast, money-saving service.

First in strain measurement

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division, Waltham 54, Mass.

SR-4® Strain Gages • Transducers • Force Measurement Systems



GIANT TRANSPORTER FEATURING ACIPCO "WALKING BEAM ASSEMBLIES" WILL HELP...

Saturn's conquest of space

The moment draws near when America's Saturn rocket will thunder into space. But in the meantime, elaborate ground preparations are now taking place.

From the N.A.S.A. Marshall Space Flight Center in Huntsville, Alabama, via a circuitous land and water route to the launching site, the missile and its valuable cargo will be gently cradled on the huge transporter shown here. Acipco walking beam assemblies (upper left) are vital parts of this transporter.

These rugged assemblies are constructed of high strength alloy steel and comprise centrifugally spun and statically cast component parts . . . all produced at Acipco. Also, all precision machining and intricate fabrication work were done by skilled Acipco personnel.

While your tubular product application may not be destined for outer space, Acipco's production "know how" and complete "under one roof" facilities can assist you, too. Your inquiry is invited.

ACIPCO
SPECIAL PRODUCTS
DIVISION OF ACIPCO **AMERICAN CAST IRON PIPE CO.**
BIRMINGHAM 2, ALABAMA

CIRCLE 27 ON READER SERVICE CARD

CASE HISTORIES

Frequency Time Standard instruments, selected by Smithsonian Institution to clock satellites, are equipped with New Departure ultra-precise ball bearings.

Photos: Courtesy Ernst Norman Laboratories and Bodine Electric Co.

Ultra Precise Ball Bearings Help "Clock" A Satellite!

CUSTOMER PROBLEM:

Require ultra-precise bearing design for Bodine electric motor used in satellite-tracking micro-clock. Bearings must provide uniformly low starting torque, precise location of rotor shaft and minimum maintenance, to help mechanism achieve time determinations to 0.001 second.

SOLUTION:

N/D Sales Engineers studied special bearing requirements, and recommended New Departure ultra-precise ball bearings. These ball bearings measured up to every requirement for micro-clock motors . . . thanks to New Departure's advanced equipment for research, development and production. N/D equipped micro-clocks, selected by the Smithsonian Institution, are operating in a dozen locations around the world, keeping track of vital satellite movements . . . to one milli-second and better!

If you're manufacturing or designing electric motors for any high precision applications, including instruments, why not call on New Departure? N/D engineering and research facilities are turning out the latest in high precision instrument ball bearings and advanced ball bearing designs. For more information write Department LS, New Departure Division, General Motors Corporation, Bristol, Conn.

NEW DEPARTURE

BALL BEARINGS

proved reliability you can build around

PRODUCT ENGINEERING HORIZONS

AUGUST 1, 1960

Simple?

A match packet is about as simple a product as can be imagined—20 matches in a paper folder. But have you noticed the variations? There are double-width packets, double-width matches, giant packets, miniature packets, strike strips on the back for safety. Europeans have packets with wood matches, packets that open at the top instead of one side, packets in which the tab must be inserted to expose the strike strip. Each adds an idea to the product, changes a material, attracts a new user. Simple? Very, but the idea content is high.

Or take a mail chute. Nothing complex there either. Except that the materials must be able to withstand 20 years or more of corrosive and damp atmospheres, the chute must be readily openable in case of a jam, there must be no internal obstructions, the high-visibility front must not be fragile, the passage must not create a fire hazard or be obstructed by building sway or settling, the entry slots must prevent jamming and drafts, etc, etc.

Take a pencil, a pen, a T-square—all simple products "with no design content." But count the variations, the endless ideas, the developments. Can these be called "simple"? Is there actually a "simple" product produced by industry today?

It is obvious that industrial products are complex, much more complex than the almost-gadgetry represented by a match packet or a pencil or the apparent simplicity of many consumer products. But in any case the idea content and the design content must be extremely high.

This has been happening in all kinds of products—an amazing increase in the amount of engineering per unit of product, continual change and refinement. Original design is to fill a need, to provide something not previously available. But resale must be a function of refinement and improvement of the design, an increase in the engineering content.

Redesign should normally result in greater simplicity, in removing the unnecessary elements while increasing versatility. For example, in ten years of development of one vacuum cleaner, the number of parts was reduced a third, without affecting efficiency or functioning.

This brings us to a paradox—*by designing for a better product, you achieve a simpler one, but the simpler one takes more engineering.*

The simple product is higher in reliability. It will cost less to make, to sell, to maintain. It is likely to *look* more functional as well as to be more functional. Our recent design contest (PE—May 23) showed again that the product that looks as if it can do its job, that looks simple, is the product acceptable to judges (who are more critical) as well as to users.

This is not a complex idea; it is, in fact, extremely simple. But it is one of the hardest to get across—that simplicity, not complexity, should be the objective of design.

R. S. Langeman

BARBER-GREENE specifies INTERNATIONAL Power

for world's leading line of asphalt plants!

Report from Guy Banister,
Chief Technical Engineer,
Barber-Greene Co., Aurora, Ill.

"We standardized on International diesels for Barber-Greene Continuous Mix Asphalt Plants in 1947, and owners' reports prove we made an excellent choice."

"For 30 years Barber-Greene Continuous Plants have played a major role in making asphalt paving the world's most used road surface. Since the 30's road builders have been able to produce a controlled high-quality mix in high volume at low cost, and that calls for *efficient power.*

"Because the whole paving operation depends on our plants for asphalt production, plant downtime can run as high as $5,000 hourly. And since engines on the plants operate under continuous load 8 to 10 hours daily—that calls for *dependable power.*

"Since Barber-Greene Continuous Mix Plants are highly mobile—often moving to 6 or 8 jobs in a season—that calls for engines supported by an *excellent parts and service organization.*

"International diesel engines meet Barber-Greene standards for efficiency, dependability, and parts and service support. That's why we standardized on IH power for these plants. Performance records over the past 13 years show that our customers, too, are satisfied International users."

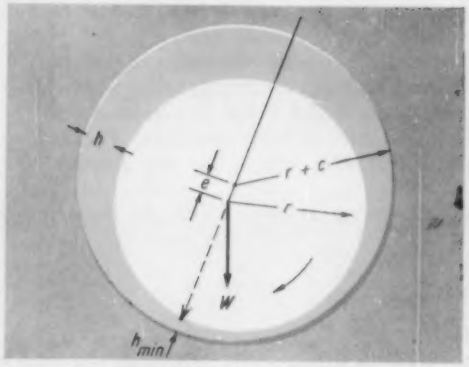
You, too, can build into your products the advantages of International power. Check the complete International engine line—35 carbureted and diesel models from 16.8 to 385 max. hp. You'll like the one common feature of all 35 engines: fastest payback power for users. Just call or write International Harvester Co., Engine Sales Department, Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL®
IH ENGINES

International Harvester Co.,
180 North Michigan Ave.,
Chicago 1, Illinois
A COMPLETE POWER PACKAGE

new concepts and charts simplify

JOURNAL-BEARING DESIGN



Although there is still no precise method for designing a simple journal bearing, the author here combines theory with test results to produce a new procedure and design chart that gives greater accuracy than methods now in use.

Dr G S A SHAWKI, *associate professor*
Production Engineering Dept
Cairo University, Cairo, Egypt

SYMBOLS

- c — radial bearing clearance (difference between bore and shaft radii)
- d — clearance ratio = c/r
- D — bearing diameter = $2r$
- e — journal eccentricity during rotation
- h — fluid-film thickness
- h_{min} — minimum film thickness = $c - e$
- J — mechanical equivalent of heat
- K — nondimensional terms = $W/\lambda N D^2$
- L — axial bearing length
- N — rotational journal speed
- P — load applied per unit projected bearing area
- p — fluid-film pressure
- r — radius of journal
- U — circumferential velocity of journal surface
- W — total load acting on bearing
- x — distance measured along journal surface in direction of motion
- y — distance measured across fluid film
- z — distance measured along bearing axis
- λ — the gamma exponent — generally dependent on the ratio L/D
- ϵ — eccentricity ratio = e/c
- γ — coefficient of viscosity of lubricant
- μ — coefficient of friction for journal

The trend in designing oil-lubricated bearings today is toward narrower and smaller bearings—but this requires a more precise design approach. Design charts in general use are based on approximations that call for generous safety factors. However, here is a modified method, checked against actual test data, which gives more precise answers and also simplifies design procedure.

This new method combines these factors: given the load, speed, shaft size and oil viscosity, you can quickly determine bearing length, clearance, frictional resistance and probable temperature rise. Values are for full cylindrical bearings, under steady load, with a continuous flow of oil supplied under pressure. The following step-by-step procedure and a numerical problem illustrate the new technique.

THE GAMMA EXPONENT

Theoretical load capacities are based on either "infinitely long" or "infinitely short" bearings; the intermediate

←CIRCLE 30 ON READER SERVICE CARD

ranges are determined by tests. A simple design method is obviously needed for this transition area; one that checks with both extremes as well as known test points in between. This has been done by introducing an empirical "gamma exponent" on load and friction factors. The exponent is a function of the L/D ratio, and modifies load and friction factors to bring them into conformity with actual test data.

Working equations for load and friction factors that require modification are based on Reynolds' differential equation, which gives the pressure developed in three dimensions in a lubricating film:

$$\left[\frac{\partial}{\partial x}\left(\frac{h^3}{\lambda}\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial z}\left(\frac{h^3}{\lambda}\frac{\partial p}{\partial z}\right)\right]=6\frac{\partial}{\partial x}(Uh)$$

In spite of extensive analytical studies, a complete solution for this equation has not been developed.

Sommerfeld's approximate solution to Reynolds' equation is still widely employed and is based on the assumption that the bearing length is so large in relation to its diameter that film pressure distribution in the axial direction may be neglected, i.e. $\partial p/\partial z = 0$. In other words, Sommerfield dealt with the case of an infinitely long bearing. His analysis led to the load criterion:

$$\left[\left(\frac{P}{\lambda N}\right)\left(\frac{c}{r}\right)\right]$$

or

$$\left[\frac{Pd^2}{\lambda N}\right]$$

where $d = c/r$.

This is a nondimensional quantity, which ties together the key factors in bearing design: P = load per unit projected area; N = journal rotational speed; λ = lubricant viscosity; and c/r = the ratio of bearing clearance to shaft radius.

Another interesting analytical solution, based on the assumption that $\partial p/\partial x = 0$, was obtained by DuBois & Ocvirk for the other extreme case of the infinitely short journal bearing (see NACA report #1157, Washington, 1953). This solution lead to the load criterion:

$$\left(\frac{Pd^2}{\lambda N}\right)\left(\frac{D}{L}\right)^2$$

A more realistic load criterion would probably lie somewhere in between. By employing the letter γ as an exponent, the load criterion can be written as:

$$\left(\frac{Pd^2}{2N}\right)\left(\frac{D}{L}\right)^\gamma$$

in which $\gamma = 0$ for infinitely long bearings, as per Sommerfeld, and $\gamma = 2$ for infinitely short bearings, as per DuBois & Ocvirk.

It is feasible to expect that for bearings of common proportions, the gamma exponent would vary between 0 and 2. This concept is backed by Kreisle's results ("Very Short Journal Bearing Hydrodynamic Performance Under Conditions Approaching Marginal Lubrication," L. F. Kreisle, 1956, Trans. ASME, New York, vol 78, p 955-963), which show a value corresponding to $\gamma = 1.73$ for short bearings.

The gamma exponent undoubtedly varies with the relative bearing width L/D. Although DuBois and Ocvirk suggested in their report that: $\gamma = 2$ for $L/D \leqq 1$ and $\gamma = 0$ for $L/D \geqq 1$, this gives an abrupt transition from the infinitely short bearing value to the infinitely long bearing value. A uniform variation between the two limits will give more realistic results. In this respect, γ should preferably be expressed as a simple function of L/D.

Based on an evaluation of previously published test results by other experimentors, and on tests the author conducted, the gamma exponent was found to vary as a function of L/D in the following manner:

For values or L/D = 1 and over.—The exponent gradually decreases as a function: $\gamma = D/L$. Note that this is the reciprocal of L/D; hence for an infinitely long bearing $\gamma = 0$. This is illustrated in Fig. 1 on facing page.

For values of L/D = 1 and under.—The exponent increases as a straight-line function: $\gamma = 2 - L/D$, thus $\gamma = 2$ with an "infinitely short" bearing.

The transition between the two curves is at $L/D = 1$. Thus γ assumes a simple, continuous and gradual change between the limits 0 and 2 and is consistent with the latest trends in theory and experimentation. For example, for certain short bearings it is in line with Kreisle's value of $\gamma = 1.73$.

Similarly the friction criterion would take the modified form:

$$\left[\frac{\mu}{d}\Big/\left(\frac{D}{L}\right)^\gamma\right]$$

in which γ varies as shown above. Other derived criteria would also incorporate in general the term $(D/L)^\gamma$.

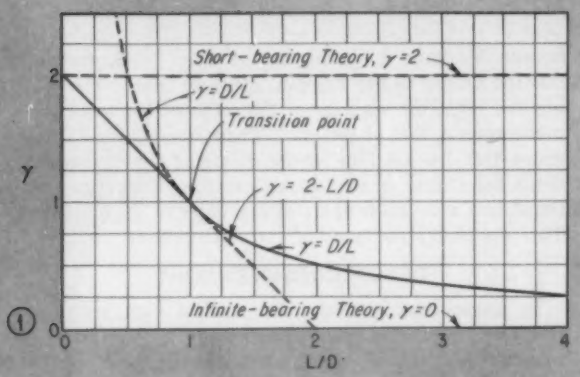
LOAD-CARRYING CAPACITY

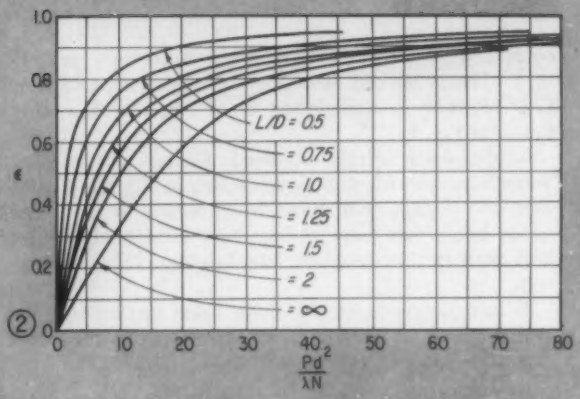
For a particular journal-bearing system, an increase in the load or the load criterion increases the eccentricity e of the shaft. The eccentricity is usually expressed in terms of a ratio ϵ which is equal to e/r. Families of curves in which ϵ is plotted against the load criterion have been developed by A. Frankel (presented as a doctorial thesis at the Eidgenossischen Technischen Hochschule in Zurich, 1944. See also The Engineers' Digest, 1946, vol 3, p 223-228, 287-290), and by A. Cameron & W. L. Wood (see "The Full Journal Bearing", 1949, Proc. Instn. Mech. E., London, vol 161, p 59-72). It will be shown that use of the gamma exponent reduces these families into almost single-line characteristics. This gives more realistic results and cuts down design time considerably.

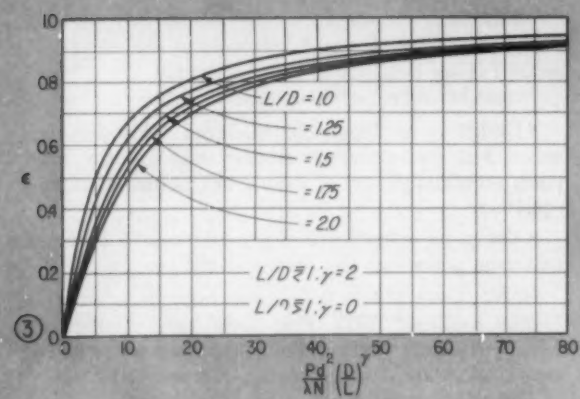
Frankel's load-capacity results, Fig 2, are plotted as ϵ versus $Pd^2/\lambda N$, for various values of L/D ranging from 0.5 to infinity. If the curves for the range of L/D greater than 1 are based on a value of $\gamma = 2$, there is some convergence, Fig. 3.

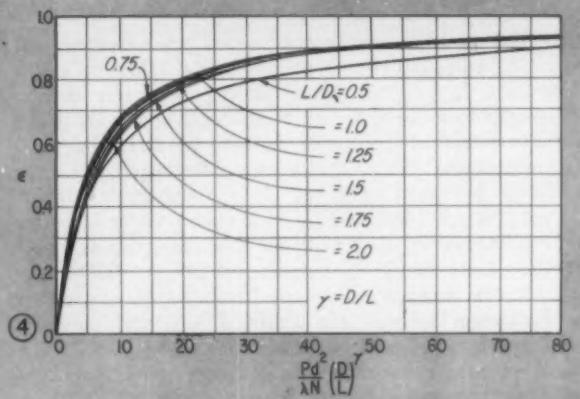
But, if Frankel's curves are modified on the basis $\gamma = D/L$ (in keeping with suggestions set previously) then a remarkable convergence toward single-line characteristics

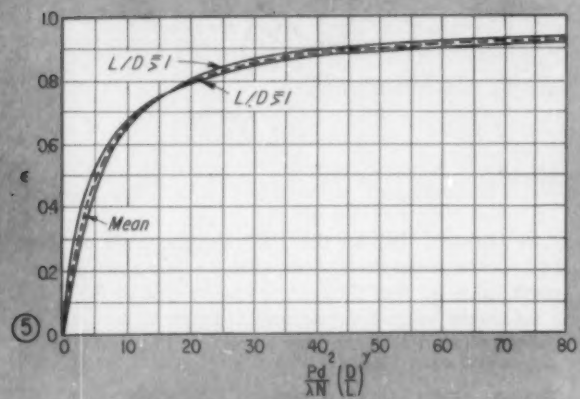
text continued on page 34

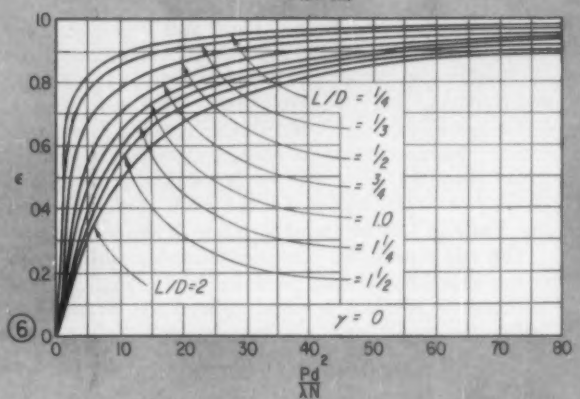


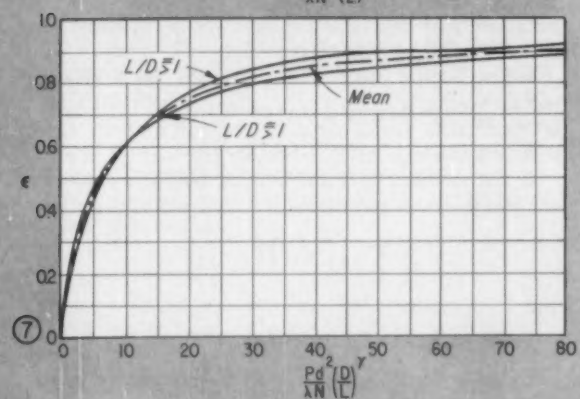












EFFECT OF GAMMA EXPONENT ON KNOWN DATA

1 - New versus old concepts of how the gamma exponent varies. New: γ equals D/L up to transition point - then equals (2-L/D). Old: γ equals either 0 or 2

2 - Frankel's conventional load-capacity results

3 - Frankel's results modified

4 - Convergence toward single-line characteristics

5 - Final modified Frankel's curves

6 - Cameron and Wood's conventional load-capacity results

7 - Convergence toward single-line characteristics

occurs, Fig. 4. But this value for γ is rather high for $L/D \leq 1$. Hence for this range, γ is given the value of $2 - L/D$ resulting in a single-line curve (the dashed mean) shown in Fig. 5.

Load-capacity curves obtained from Cameron and Wood's analysis for $\gamma = 0$, are shown in Fig. 6. Curves were also plotted (not shown here) with $\gamma = 2$. These curves imply that short bearings have substantially higher load capacity than relatively long bearings. This is incorrect.

When the curves of Fig. 6 are based on the modified load criterion, they show a good convergence towards a single-line load capacity curve, Fig. 7.

COMPARISON WITH EXPERIMENTAL DATA

The modified load-capacity curves are compared with the experimental results obtained by the author on a 4 in. dia x 6 in. long full journal bearing, using nine thermocouples to measure the oil temperature at various points. (For details on this testing machine see the author's previous papers "Whirling of a Journal Bearing: Experiments Under No-load Conditions," 1955, Engineering, London, vol 179, p 243-246; and "Journal-bearing Performance Under Sinusoidally Alternating and Fluctuating Loads," 1955, Proc. Instn. Mech. E., London, vol 169, p 689-698.)

Points obtained from the tests, Fig. 8, show a marked inclination towards the modified analytical curves of Frankel, Fig. 5, and of Cameron & Wood, Fig. 7. The curve based on the short-bearing theory, on the other hand, deviates considerably from the test results.

The modified load factors, Fig 5 and Fig 7, are next compared with experimental results determined by W. Nucker (published in VDI Forschungsheft 352, Berlin) and A. Rumpf (VDI Forschungsheft 393, Berlin), Fig. 9. Close agreement is shown to exist between these four curves. Moreover, they all show a much lower load capacity than that predicted by the short-bearing theory. Hence it is recommended that the mean of the curves of Fig. 5 or Fig. 7 be employed in future design work.

The test results also compared favorably with the extensive experimental data presented by DuBois, Ocvirk & Wehe in a NACA Technical Note 3491, Washington 1955.

FRICTION CHARACTERISTICS

Friction values from Cameron & Wood's analysis exhibit a remarkable convergence to a single-line characteristic, Fig. 10, when based on the modified load and friction criteria.

Analytical curves derived from data of Frankel and Cameron & Wood are next compared with the experimental results reported by DuBois, Ocvirk & Mabie, also with the author's results, Fig. 11. Dubois' results for $L/D = 1$, $\frac{1}{2}$, and $\frac{1}{4}$ closely coincide with the short-bearing theory ($\gamma = 2$), but could be converted by having $\gamma = (2 - L/D)$. Test points would still lie above the author's line. It can be seen that mean experimental friction values assume a mean position near the author's curve.

However, Frankel based his analysis on a friction-generating film extending over only half the bearing circumference; Cameron & Wood, on the other hand, assumed that shear stress in the lubricant exists all around the bearing and "that the viscosity of the oil to oil-vapor mixture is the same as that of the oil." There is experimental evidence that the oil film in the divergent region narrows down and breaks up into streamlets, thus leading to fractional film area under shear of the order of 75 to 100%. This would explain many of the discrepancies.

DESIGN CONSIDERATIONS

In journal-bearing design, the applied load, rotational speed and journal diameter are usually known, and the lubricant viscosity is estimated in the light of relevant data and available experience.

Under these circumstances, the journal may be made to run at any desired eccentricity ratio by selecting appropriate bearing clearance and journal width.

Remember these two basic requirements:

- Design for maximum film thickness. This gives minimum wear, and permits maximum misalignment, maximum out-of straightness of journal and maximum safety of operation.
- Design for lowest value of journal friction. This gives minimum power loss and heating in the bearing.

H. W. Swift ("The Stability of Lubricating Films in Journal Bearings," 1932, Proc Instn. C.E., London, vol 233, p 267-286) developed the film thickness and frictional criteria for a partial bearing of infinite width:

The film-thickness factor:

$$\frac{h_{min}}{r}\left(\frac{P}{\lambda N}\right)^{1/2}$$

and the friction factor:

$$\mu\left(\frac{P}{\lambda N}\right)^{1/2}$$

where

$$h_{min} = c - e = (1 - \epsilon)c$$

Swift found that for the 180° bearing, plots of these two criteria versus eccentricity ratio ϵ would show a maximum value for film thickness criterion at $\epsilon = 0.37$, and a minimum value for frictional criterion at $\epsilon = 0.5$. A compromise value of $\epsilon = 0.4$ was taken and is still being used today by many designers. In fact, it is commonly assumed that ϵ should not exceed 0.5. However, it will be shown that this value not only can be exceeded—but for best results, should be exceeded.

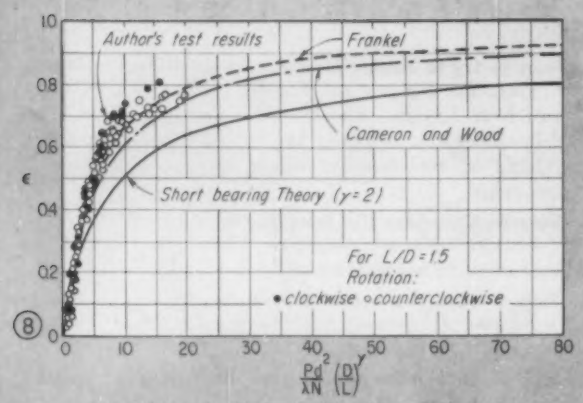
When Swift's concepts are modified for a complete journal bearing of finite width, using Frankel's or Cameron & Wood's data, sets of curves are obtained for both criteria, with max and min values extending over a range of ϵ.

If the modified load and friction criteria are adopted, the film thickness and frictional criteria will take the form:

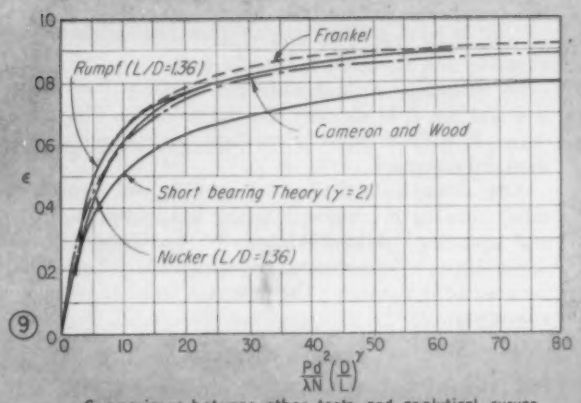
$$\frac{h_{min}}{r}\left[\left(\frac{P}{\lambda N}\right)\left(\frac{D}{L}\right)^{\gamma}\right]^{1/2}$$

and

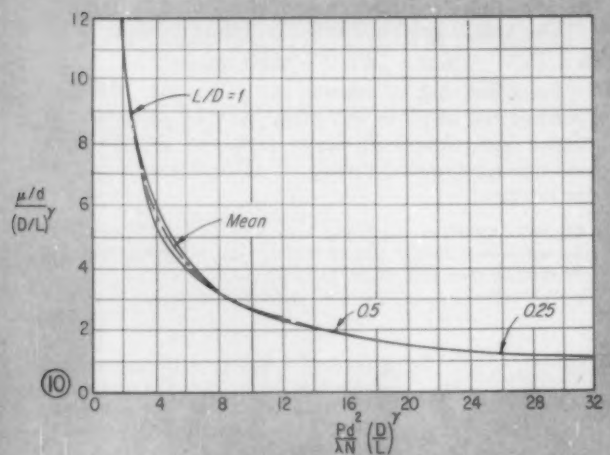
$$\mu\left[\left(\frac{P}{\lambda N}\right)\Big/\left(\frac{D}{L}\right)^{\gamma}\right]^{1/2}$$



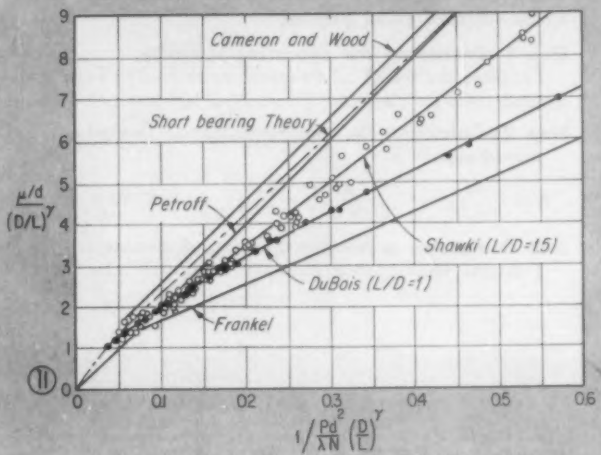
Comparison of author's results with analytical curves



Comparisons between other tests and analytical curves



Cameron and Wood's friction results
(based on modified criteria)



Author's friction data compared with other results

Modified film thickness and frictional criteria versus eccentricity ratio ϵ are plotted for the complete journal bearing of finite width using Frankel's and Cameron & Wood's single-line load and friction characteristics based on modified criteria. The highest value for film thickness takes place at $\epsilon \sim 0.425$ to 0.50, and the lowest friction value occurs at $\epsilon \sim 0.7$ to 0.75. A compromise for maximum film thickness and minimum friction for the finite journal bearing would thus be attained at $\epsilon \sim 0.6$, as compared to the value of 0.4 commonly employed.

For convenience in design computations, the modified load factor can be put in the form:

$$\left(\frac{Pd^2}{\lambda N}\right)\left(\frac{D}{L}\right)^{\gamma} = \frac{Wd^2}{\lambda N D^2}\left(\frac{D}{L}\right)^{\gamma+1} = K\left[d^2\left(\frac{D}{L}\right)^{\gamma+1}\right]$$

Factors in the term $K = W/\lambda ND^2$ are usually known to the designer. Factor K is nondimensional because viscosity is equal to force x time/length^2.

Practical values of the relative bearing clearance d range from 0.001 to 0.002. For optimum operating conditions:

$$K\left[d^2\left(\frac{D}{L}\right)^{\gamma+1}\right] \approx 8.5$$

The value of the minimum film thickness h_{min} should lie within safe limits consistent with bearing size, journal speed, quality of bearing surfaces and other service conditions. By definition

$$\frac{h_{min}}{D} = \frac{c(1-\epsilon)}{D} = \frac{d(1-\epsilon)}{2}$$

Factors K, h_{min}, d and L/D are combined in the design chart, Fig. 12. Here h_{min}/D is plotted against L/D for various values of K. The K-lines in color are for $d = 0.001$, and the solid K-lines for $d = 0.002$. Some sort of interpolation can be done for the range in between. Avoid

JOURNAL-BEARING DESIGN continued

the extreme areas above and below. The chart is based on the mean single-line load characteristic derived from Frankel's and Cameron & Wood's data.

By computing K, and arbitrarily selecting $d = 0.001$, you find the L/D directly, also the minimum film thickness. If L/D obtained is too high for the application, then d is increased.

After determining the bearing geometry and eccentricity ratio, calculate the frictional power loss, temperature rise and operating lubricant viscosity. The assumed initial values can now be corrected, and design computations can be repeated if necessary. The process is found to be rapidly convergent.

SAMPLE PROBLEM

• Design a journal bearing to support a 3200-lb load. The journal rotates at 2800 rpm. Journal dia = 2 in.; SAE 10 oil supplied under pressure:

Step 1—Determine the operative viscosity.
Estimate the outlet oil temperature to be 170 F (a reasonable value). Therefore $\lambda = 1.23 \times 10^{-6}$ reyns.

Step 2—Calculate the nondimensional design parameter.

$$K = \frac{W}{\lambda N D^2} = \frac{3200 \times 60}{1.23 \times 10^{-6} \times 2800 \times 2^2} = 13.94 \times 10^6$$

Step 3—Assume a relative bearing clearance.
Practical values range normally from 0.001 to 0.002; extreme values about 0.0005 and 0.003. Hence select $d = 0.001$.

Step 4—Try to design for optimum bearing conditions.
From the design chart, Fig 12, $L/D = 1.27$. Therefore $L = 2.54$ in. Also from the chart $h_{min}/D = 0.2 \times 10^{-3}$. Thus $h_{min} = 0.0004$ in. Should these values not be reasonable, the choice of oil or bearing clearance must be revised.

Step 5—Calculate the load factor.
Because optimum conditions have been attained, the load criterion is approximately 8.5.

Step 6—Find the eccentricity ratio.
Because of optimum conditions, $\epsilon = 0.6$. Otherwise use Fig. 5 or Fig. 7.

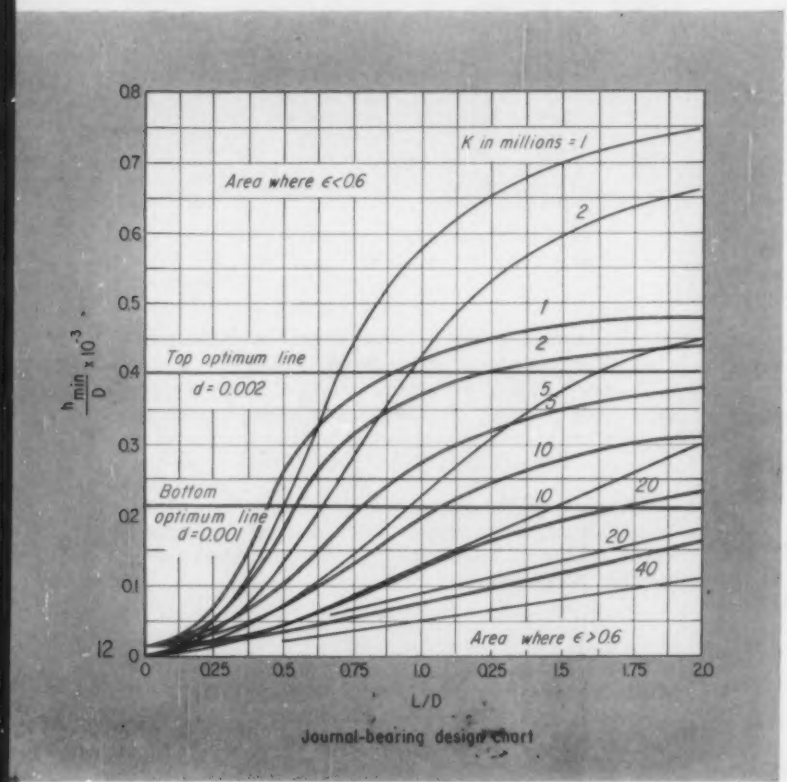
Step 7—Determine the journal coefficient of friction.
From Fig 11 (mean value), $\mu = 1.8 \times 10^{-3}$.

Step 8—Calculate rate of heat generated in fluid.
The heat is generated because of fluid friction.

$$\text{Rate} = \mu WU/J = 0.1825 \text{ btu/sec}$$

From this, and by knowing the oil-flow rate, the temperature rise of oil in the bearing can be estimated. If higher than assumed or can be permitted, the flow rate, through appropriate grooving, or oil feed pressure should be increased.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, N. Y.



Journal-bearing design chart

EDITOR'S NOTE—For applications where it is not economical or feasible to provide oil to the bearing under pressure, see these types of journal or sleeve bearings:

Alloyed Plastics Give Oilless Bearing, May 25, '59, p 58. A new oilless bearing material has appeared with high load capacity and low coefficient of friction.

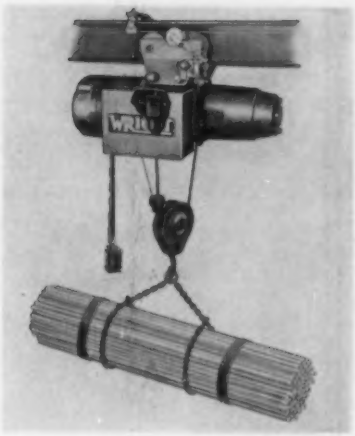
Nylon-clad Sleeve Bearings, Mar 3 '58, p 52. Nylon-11 acts as a cladding for metal sleeve bearings by providing a surface that takes high load and needs no lubrication.

Experts Strip Mystery from Gas Bearings, Nov 23 '59, p 68. An on-the-spot report on the First International Symposium on Gas-lubricated Bearings held in Washington, DC.

The Step Bearing . . . A New Concept in Air Lubrication, Dec 8 '58, p 96. Gives details of Boeing's method of providing tiny steps in the shaft or housing to increase stability.

Solid Aluminum Bearings, July 4 '60 p 42. To minimize starting friction and prevent seizure, successful application depends on proper selection of materials and design characteristics. Aluminum bearings, increasingly popular, are analyzed here in detail.

Selecting the Right Journal-bearing Material, Sep '52, p 119. Gives comparative properties of white-metal alloys, copper-base alloys, silver cast iron, graphite and others.

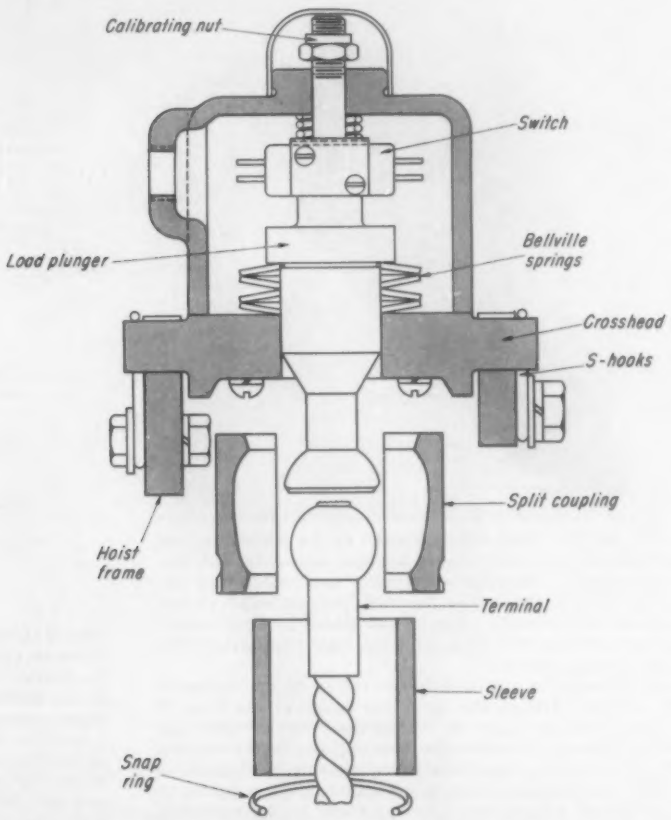


SWITCH AND SPRING elements are sealed for mechanical protection and to prevent tampering. The overload-cutoff is calibrated at the factory and sealed. Unless the switch wires are bypassed deliberately, normal operation is insured. A sudden, accidental overloading—for example, if the load is dropped—could cause the switch to fail or fracture. If it does, switch is fail-safe; lifting circuit can't operate until switch is repaired or replaced.

PS . . . Primarily intended to protect the operator and secondarily to prevent damage to equipment, overload-cutoff prevents the lifting of loads greater than the capacity of the hoist. It's standard equipment on new frame-2 and frame-3 electric hoists; can be fitted to all older models. Produced by Wright Hoist Div, American Chain & Cable Co Inc, York, Penna.

Cutoff Prevents Overloading of Hoist

Fail-safe switch deactivates lifting circuit if load exceeds preset value. Split coupling permits quick attachment of cable.

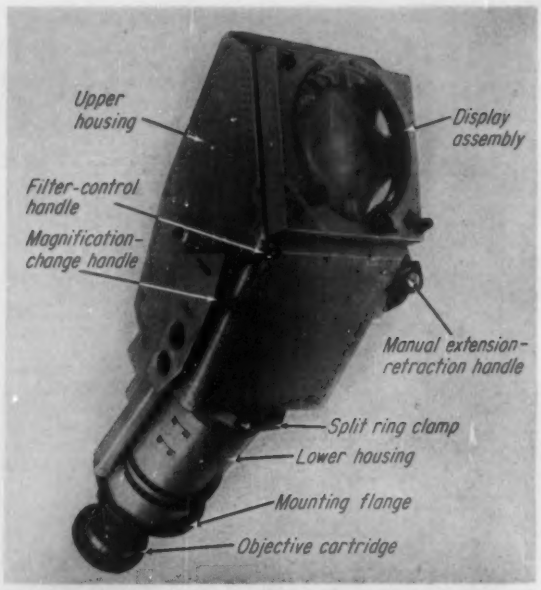


LOAD PLUNGER is inserted through the Belleville springs, which are supported on a swiveling crosshead. The crosshead is mounted on the hoist frame and retained by two S-hooks and bolts. Under load, the Belleville springs deflect and permit the load plunger to move axially. The end of the load plunger is connected to a normally closed switch. When the springs deflect beyond a preset value, the load plunger trips the switch opening the raising-coil circuit of the magnetic hoist-controller. The raising circuit becomes inoperative, but the lowering circuit is not affected. A second contact, normally open, is included in the switch to permit the inclusion of visual or audible overload signal devices.

The load plunger and the swaged-on cable termination have ball-and-socket seat sections to permit maximum free cable movement, reducing the possibility of fatigue failure. A split-coupling and sleeve permits quick attachment of the cable-ball terminal to the load plunger.

PERISCOPE WILL GUIDE MAN IN SPACE

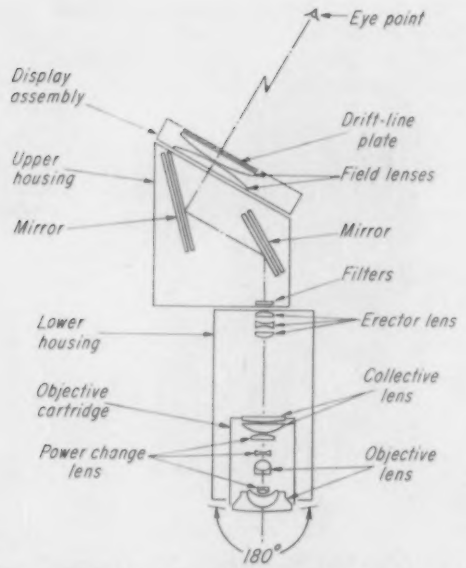
Optical system for Project Mercury satellite covers approximately 180° field to give astronaut visual information necessary to calculate capsule's position and altitude.



THREE MAJOR ASSEMBLIES make up the periscope; the lower housing assembly, upper housing assembly, and display assembly. The display assembly is mounted in a circular opening in the top of the unit, perpendicular to the observer's line of sight. Upper and lower housing assemblies are held together by a split-ring clamp that draws the mating flanges together.

The periscope is attached to the inside of the capsule's shell by bolts through the mounting flange at the base of the lower housing assembly. Since the objective cartridge extends through the periscope door opening in the capsule shell when in use, the inside lower housing is exposed to ambient atmospheric pressure. To maintain the integrity of the cabin-seal system, seals are provided at the mounting flange and all other openings in the lower housing.

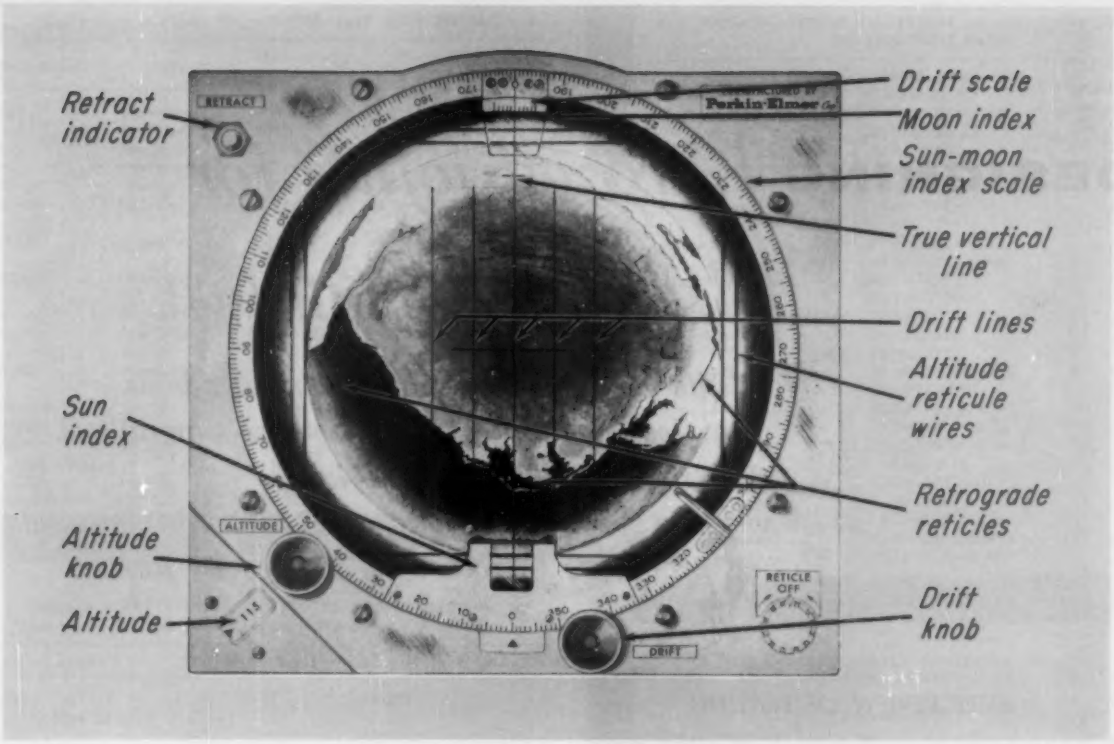
PS . . . Prime purpose of the system is to allow the operator to make altitude, attitude, direction and position measurements while in space. Secondary purpose is to observe parachute deployment during and after reentry. The 43-lb periscope is 14 in. wide, 13 in. deep, 32 in. high with optical cartridge retracted, and 38 in. high with cartridge extended. Periscope system was designed for NASA's Project Mercury manned space-capsule by Perkin-Elmer Corp, Norwalk, Conn under contract to McDonnell Aircraft Corp, St Louis, prime contractor for the capsule.



OPTICAL SYSTEM uses a wide-angle objective lens, which gives an extremely wide field (approximately 180°). Since the earth's horizon subtends an angle of approximately 151° at an altitude of 115 nautical miles, the wide field gives ample coverage for required navigational data.

Light gathered by the objective lens passes through the collective lens, where the first image is formed. This image is relayed by the erector lens through the mirror system and field lenses to the final focal plane. The final image is real, upright and can be seen by the unaided eye at a distance of two feet. The two mirrors fold the optical path, reducing over-all length, and position the visual display at the most suitable angle for the observer. Four filters—clear; yellow; neutral, medium-density; and red—are mounted in a filter plate which can be rotated to position the required filter in the optical path.

The objective cartridge is mounted inside the lower housing assembly by means of drive-screw mechanism. This mechanism can be actuated manually or by an electric motor drive to extend and retract the cartridge. A mechanical link connects the cartridge to a periscope door in the capsule skin; it opens the door as the cartridge is extended and closes the door as the cartridge is retracted.

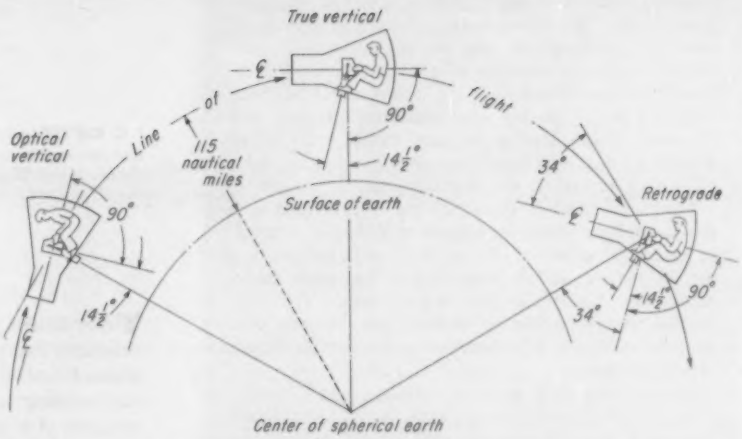


PERISCOPE DISPLAY incorporates reticle marks and associated controls, which enable the observer to determine the altitude and attitude of the satellite with respect to the earth. Relative bearings of the sun and moon also can be calculated, when they are close to the earth's horizon.

Fine, parallel lines etched on face of rotating drift plate determine drift. The periscope is set for high-power magnification and the drift knob rotated until the ground track of the vehicle parallels the drift lines. The position of the drift line with respect to the drift scale indicates the drift angle.

Altitude may be determined when the periscope is optically vertical with respect to the earth. This occurs when the capsule is pitched nose-down at 14½°, with no roll. Turning the altitude knob moves the reticle wires; this changes the size of the square and also rotates the scale of the altitude indicator. When the earth's image is inscribed within the inner square formed by the reticle wires, the altitude is indicated in miles. The center crossline reticle at the center of the display area shows the point on the earth's surface directly below the vehicle.

Pitch and roll can be approximated by the altitude mechanism. The distance between the inner and outer lines is equivalent to a 5° angle at an altitude of 115 nautical miles. Fore-and-aft reticle wires indicate pitch position, lateral reticle wires indicate roll position.



True vertical attitude, as compared with the optically vertical attitude, is achieved when the longitudinal axis of the capsule is perpendicular to a line through the center of spherical earth. This occurs when the nose of the capsule is pitched up until the horizon image is tangent to the true vertical line located near the top of the display area.

When capsule assumes retrograde angle (34° nose-down pitch), the horizon image at the bottom of the display is tangent to the three retrograde reticles which form an arc across the lower half of the display area.

Four reticles located to the right center of the display area indicate the field of view of the earth-sky camera included in the capsule.

Sun-moon index scale frames the display area and is rotatable by fingertip. The indicators, mounted 180° apart on the index ring, are used to take readings when the capsule is optically vertical and the drift angle is zero. Bearings are read off the index scale at the index mark located directly in front of the observer on the display centerline.

DESIGNING / *brazed joints for 1000 F and above*

High-temperature brazing efficiently joins stainless steels, alloy steels and the superalloys. This roundup tells how it works, when to specify it, how to select the right materials, and procedure to follow to get design started.

J C REEVES, *welding engineer*
Materials and Process Section
The Marquardt Corp
Van Nuys, Calif

A BRIEF REVIEW OF BRAZING

Brazing is a joining process where the filler metal has a melting point above 800 F, but below that of the metals being joined. The melted brazing alloy fills all parts of the joint by capillary action, wets the base metal and, upon cooling, forms an intimate metallurgical bond with it. Brazing is usually specified: (1) When the base metal requires a joining process using intermediate temperatures to avoid strength loss or structural change. (2) When distortion must be avoided and close dimensional tolerances must be held on the parts being joined.

Most production precision brazing is performed in a furnace under a protective blanket of hydrogen, inert gas or dissociated ammonia. Temperature and atmosphere in the furnace are carefully controlled so that joints are reproducible. Vacuum furnaces are also used. Other important production heating methods are: dip, salt bath, electrical resistance, induction heating, multiple gas-burners and radiant lamps.

Most brazing filler metals are alloys, carefully tailored from several elements to match the metal being joined. Four main characteristics of a good brazing alloy are: (1) ability to wet the base metal; (2) melting temperature well below base-metal solidus, and proper degree of fluidity, (3) sufficient homogeneity and stability to minimize separation by differential melting; (4) mechanical and physical properties close to those of the base metal.

Silver-base and copper-base alloys are the most common fillers, but are limited to continuous service temperatures well below 1000 F. Above this point, fillers with much higher melting points must be used—such as nickel-base and chromium-base alloys, or combinations of noble metals. Most filler alloys used in production brazing can be obtained in the form of foil, sheet or wire. These forms can often be preshaped into rings, washers or gaskets to simplify production.

Table I lists 15 metals and alloys commonly used in structures that must carry loads continuously above 1000 F without corroding. Until recently, fusion welding, resistance welding, and mechanical fastening were the accepted methods of joining for these materials. Now, after several years' experience with high-temperature brazing alloys, furnace brazing is proving a rapid and reliable method of assembly that can be readily adapted to continuous production.

Main advantage of the process is that several joints can be made simultaneously, often in positions not readily accessible for other joining techniques. This is achieved by using a preplaced brazing alloy. Another advantage: dimensional and metallurgical changes are carefully regulated through close control of brazing temperature.

The major limitation is that the metallurgy of a brazed joint is often more complex than for a weldment. Accordingly, development of suitable brazing alloys for high-temperature metals has been slow and largely empirical.

Table I — TYPICAL HIGH-TEMPERATURE BASE METALS

Base Metal	Type	Melting Range, F	Major Constituents, %
321	Stabilized SS	2550-2600	18 Cr–10 Ni–Bal Fe
347	Stabilized SS	2550-2600	18 Cr–11 Ni–Bal Fe
405	Ferritic SS	2700-2790	13 Cr–Bal Fe
431	Martensitic SS	2550-2650	16 Cr–2 Ni–Bal Fe
Inconel	Ni-base	2550-2600	15 Cr–77 Ni–7 Fe
Hastelloy C	Ni-base	2318-2381	16 Cr–6 Fe–5 W –17 Mo–Bal Fe
N-155	Mixed-base	2325-2475	20 Cr–20 Co–20 Ni–3 W –3 Mo–Bal Fe
R-235	Ni-base (PH)	2360-2420	16 Cr–7 Fe–5 Mo–2 Al –3 Ti–Bal Ni
Monel	Ni-base	2370-2640	30 Cu–Bal Ni
Nickel	Low-C type	2650	99 Ni–Bal Si, Mn, Fe and Cu
S-590	Mixed-base	2400-2500	21 Cr–20 Ni–20 Co–4 W –4 Mo–4 Cb–Bal Fe
Haynes Alloy 25	Co-base	2425-2570	20 Cr–10 Ni–2 Fe –15 W–Bal Co
Haynes Stellite 21	Co-base	2550	28 Cr–3 Ni–2 Fe –5 Mo–Bal Co
A-286	Fe-base	2500-2600	15 Cr–25 Ni–Bal Fe
Molybdenum		4752	100 Mo

Table II — TYPICAL ALLOYS USED AS HIGH-TEMPERATURE BRAZING FILLER METAL

Alloy	Nominal Composition, %	Liquidus Temp., °F
AMS 4778	93 Ni–3 Si–3 B	1820
AMS 4777	82 Ni–7 Cr	1830
Wall Colmonoy No. 6	78 Ni–18 Cr–4 B	1950
AMS 4776	78 Ni–18 Cr–4 B	1970
WG (wide gap) Nicrobraz	78 Ni–12 Cr	2000
Nicrobraz 30	79 Ni–19 Cr	2075
Nicrobraz 170	64 Ni–12 Cr–16 W	2150
Palladium–copper	60 Pd–40 Cu	2200
Palladium–nickel	53 Pd–47 Ni	2200
Silver–platinum	70 Ag–30 Pt	2200
Super nickel 326	70 Cu–30 Ni	2240
Monel	70 Ni–30 Cu	2370
Hastelloy C	57 Ni–17 Mo–16 Cr –6 Fe–4 W	2380
Palladium–silver	60 Pd–40 Ag	2500
Inconel	77 Ni–15 Cr–7 Fe	2540
Haynes Stellite 21	62 Co–28 Cr–3 Ni– 5 Mo–2 Fe	2550
Haynes Alloy 25	55 Co–20 Cr–15 W–10 Ni	2600
18-8 Stainless	18 Cr–8 Ni–Bal Fe	2600
20-25 Stainless	25 Cr–20 Ni–Bal Fe	2650
Kanthal A-1	70 Fe–25 Cr–5 Al	2700

Table IV — EFFECT OF BRAZING ALLOY ON JOINT STRENGTH
(Base metal is molybdenum, induction-brazed, with slotted joints)

Brazing Alloy	Shear strength at 1800 F, psi
Inconel	18,800
Haynes Alloy 25	14,300
Monel	12,800
Hastelloy C	12,000
Haynes Alloy 21	12,000
Palladium–nickel	9,400
Silver–platinum	7,200
Palladium–copper	6,400
Palladium–silver	4,500
Kanthal A-1	3,400

Table III — EFFECT OF SERVICE TEMPERATURE ON JOINT STRENGTH
(Butt joints brazed with Ni–Cr filler alloy)

Base Metal	Base-metal UTS, psi x 1000			Brazed-joint UTS, psi x 1000		
	70 F	1200 F	2000 F	70 F	1200 F	2000 F
347 stainless	90	53	...	90	47	...
431 stainless	190	...	...	142	...	...
A-286	142	112	...	90	92	...
S-590	135	95	15	119	93	15

Design data have been sought only when a particular brazing problem had to be solved. This article summarizes some of these data for ready reference, explains the important factors to be considered, and gives a five-step procedure to guide design.

SELECTING A BRAZING ALLOY

For service temperatures above 1000 F, a filler metal with a high melting point is essential. A common one is copper (M.P. = 1980 F). But copper alone does not have any appreciable corrosion- and oxidation-resistance, and joint strength drops off rapidly at elevated temperature. Table II shows twenty brazing alloys–some commercial, some experimental–that are based on more stable high-temperature elements like nickel, chromium, cobalt and the noble metals. Note that some of these brazing alloys appear also in Table I. In principle, any metal or alloy from either table that has a liquidus temperature 300-400 F below that of another can be used as the brazing alloy. In practice, other factors like extreme alloying and diffusion rates narrow the choice.

The most common misconception about brazing high-temperature metals and alloys is that joint strengths at service temperatures are always much lower than the base-metal strength. Actually, as Table III shows, this strength loss, in a well-brazed joint, is nominal. These data are for butt joints; however, similar maintenance of strength can be expected on lap joints.

Picking the right brazing alloy is essential for strong joints. If the filler alloy and base metal are in the same metallurgical family, the difference between optimum and actual strength will not be great. When the two metal systems are not compatible, the drop can be startling–as shown in Table IV for molybdenum. Here, Haynes Alloy 25 appears to be the best cobalt-base brazing alloy, and Inconel the best nickel-base alloy. Short-time tensile strength of molybdenum at 1800 F is about 30,000 psi.

Joint clearance requires careful control. Brazing alloys

Table V — EFFECT OF CLEARANCE ON JOINT STRENGTH
(Alloy brazed: N–155; all failures in butt joint)

Brazing Alloy and Cycle	Clearance, in.	UTS, psi	0.2% YS, psi
Ni–Cr–B (Brazed at 2200 F for 30 min. following 30 min. preheat of base metal at 2000 F)	0.000	106,800	46,000
	0.002	57,400	44,900
	0.004	50,900	49,200
Ni–Cr–Si (same as Ni–Cr–B)	0.000	94,200	45,600
	0.002	47,800	43,950
Au–18 Ni (Brazed at 1950 F for 10 min., no preheat)	0.000	120,500	65,000
	0.002	129,600	73,000
	0.004	124,350	71,700
	0.006	117,750	64,300

Table VI — EFFECT OF BRAZING TIME ON JOINT STRENGTH
(Butt joints with zero clearance, as-ground surfaces, brazed at 2200 F)

Base Metal	Brazing Alloy	Brazing Time, min.	UTS, psi x 1000
N-155	Ni–Cr–B	30	101.8
		5	98.6
	Ni–Cr–Si	30	89.3
		5	72.6
347 stainless	Ni–Cr–B	30	76.6
		5	71.6
	Ni–Cr–Si	30	83.8
		5	82.2

Table VII — EFFECT OF SURFACE FINISH ON BUTT JOINT STRENGTH
(B = Blasted with No. 80 steel; G = Ground to 20 microinch)

Base Metal	Brazing Alloy	Surface Finish	UTS, psi x 1000
N-155	Ni–Cr–B	B	89.6
		G	101.8
	Ni–Cr–Si	B	96.2
		G	89.3
	Au–18 Ni	B	119.8
		G	121.3
405 stainless	Ni–Cr–Si	B	94.1
		G	90.7

are very fluid, and excessive clearance can result in loss of brazing alloy. As Table V shows, most filler metals give maximum joint strength when clearance is reduced to a minimum. A touch, or slight force-fit is desirable, but not always possible in view of achievable manufacturing tolerances. Some brazing alloys, as Table V indicates, reach optimum strength at about 2 mils clearance. Zero to 2 mils is thus considered a good area for design. Where no data exists, or none can be extrapolated, simulated joints must be brazed and tested.

PROCESS VARIABLES INFLUENCE DESIGN

Assuming a suitable brazing alloy and brazing temperature are chosen, there are three process variables that influence joint strength:

(1) Furnace atmosphere

In high-temperature brazing, controlled atmospheres usually replace conventional fluxes to prevent oxide formation (also, many brazing alloys are designed to be self-fluxing). Four basic atmospheres are commonly employed:

Dissociated ammonia is suitable for the chromium-bearing alloys, with a special flux also required if the alloy contains appreciable quantities of such reactive elements as aluminum, titanium, silicon, or beryllium.

Deoxygenated and dried hydrogen is widely used for these reactive metals themselves, as well as for cobalt, chromium and tungsten alloys, and carbide cermets.

Purified inert gases such as argon and helium are suitable for brazing alloys of cobalt, chromium, tungsten, titanium, zirconium and hafnium alloys–as well as carbides of these. Parts must be extremely clean, however.

Vacuum is a good atmosphere for brazing any metal at any temperature, provided the metal's vapor pressure at melting is not excessively high. Base metals or brazing alloys containing cadmium or zinc are unsuitable for this reason. Fig 1 compares the influence of vacuum atmosphere and hydrogen atmosphere on the shear strength of two high-temperature alloys.

(2) Brazing time

Influence of brazing time is shown in Table VI for two common alloys. These data show that longer brazing times can increase strength. However, alloying and diffusion–the means by which brazing alloys adhere to base metals–are highly time-dependent, and too much time at temperature may result in a brittle joint. Or so much of the brazing alloy may be absorbed that fillet radii are sharply reduced, increasing stress concentration. It is best to test any new metal combination to determine the most suitable brazing time.

(3) Surface finish on the base metal

Careful precleaning is, of course, required. Beyond this, actual surface roughness plays a part as shown in Table VII. A slightly roughened surface aids brazing and increases strength; a finely ground surface impedes wetting and reduces strength. However, the surface must not be so rough that capillary flow is impaired. A spreading test, on a simple geometry like a corner-butt joint, will usually indicate the limit of tolerable surface roughness.

DESIGN PROCEDURE

Designing a high-temperature brazed joint is complex mainly because the choice of base metals and filler alloys is so wide, and because brazed-joint data–like that summarized in this article–is hard to find. Here is a five-step program that logically organizes what needs to be done to overcome these obstacles.

Step 1: Rough out the design. This preliminary analysis

Effect of furnace atmosphere on two high-temperature alloys

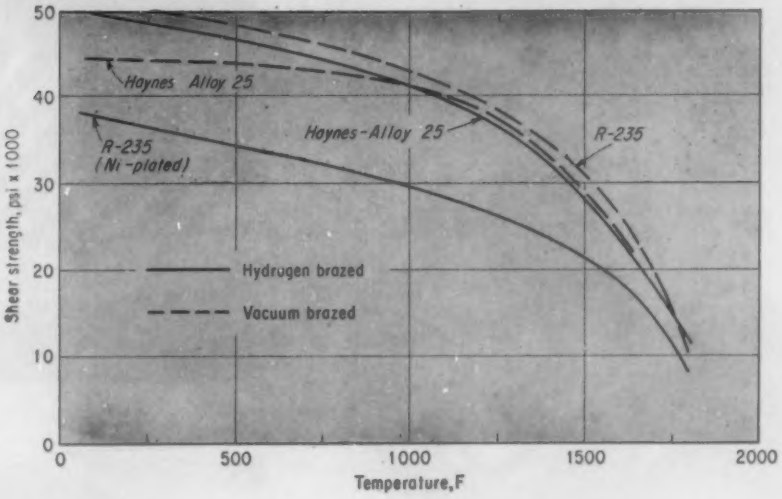


Fig 1—HAYNES ALLOY 25 has a cobalt base. R-235 is a precipitation-hardening nickel-base alloy. PH-alloys contain aluminum and titanium, and thus require either a special flux in addition to the controlled atmosphere, or a 1-mil flashcoat of nickel prior to brazing. Strength values for R-235 brazed with a flux are about 10% higher than Ni-plated curve shown here. All joints for these curves were the single-lap, zero-clearance type. R-235 specimens were solution-treated at 1950 F for 30 min., air-cooled and aged 4 hrs at 1650 F after brazing.

Stress-rupture strength for brazed molybdenum

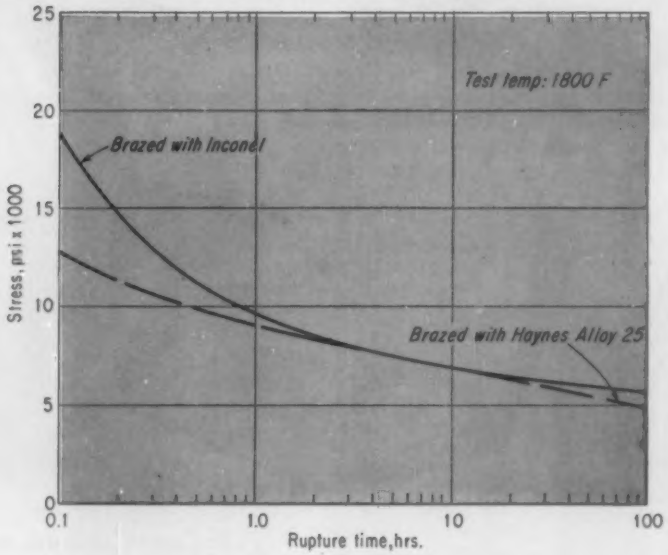


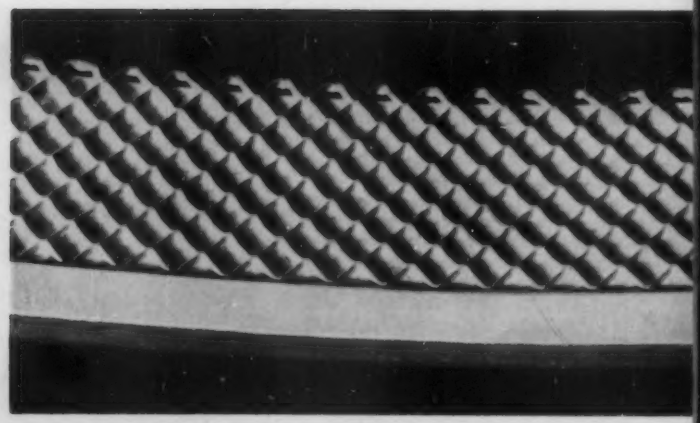
Fig 2—THE RUPTURE-STRESS values for these curves were obtained with induction-brazed specimens with double-shear, slotted joints. Brazing time for Inconel-Mo joints was 6 sec., and 5 sec. for Alloy 25-Mo joints. After brazing-alloy flow, all specimens were held for an additional 5 sec. All failures occurred in brazed joint.

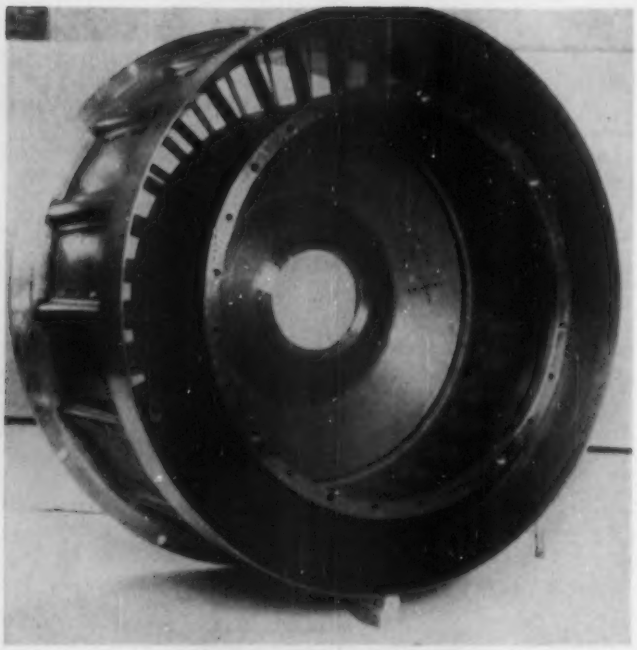
should center on the number of joints and their location. Fusion welding will be more economical if there are only a few joints, if they are easily accessible, and if distortion is not crucial. But if the design has blind joint areas, regardless of number, brazing should be considered from the outset.

Service conditions (pressure, temperature, external loads) need examining to determine the strengths required at the joints. Select a series of potential combinations of base metals and brazing alloys. Do not exclude a likely looking material system simply because design data are not immediately available. At this point, calculate rough material costs and subfabrication costs to determine whether brazing still seems feasible.

Step 2: Examine potentially suitable materials. Ultimate tensile strength (UTS), yield strength (YS) and thermal-expansion coefficient of the base metal are the first concern, particularly at elevated temperatures. Thermal-expansion values are needed most when it is likely that dissimilar metal will be used. There are several excellent sources for high-temperature data on both new and established heat-resistant alloys: Reports of government-sponsored evaluations available through OTS, Dept. of Commerce; reports and memoranda from Defense Metals Center, supported by Federal funds at Battelle Memorial Institute; individual vendor technical literature; books on high-temperature materials available from most publishers; and technical papers and articles. This last source is most fruitful and accessible through common industrial indexes.

text continued on page 45





THESE FOUR ASSEMBLIES show how high-temperature brazing can make multiple joints simultaneously, many of them inaccessible to fusion or resistance welding. Furnace brazed by the Special Products Division of ITE Circuit Breaker Co, Philadelphia, the structures utilize both sheet metal and cast parts. Reading clockwise, from top left: **TURBINE DIAPHRAGM** for jet engine has been successfully brazed from several alloys—A-286, R-235, Haynes Alloy 25, or Rene 41. **SEAL** for jet engine turbine wheel is brazed from nickel-alloy honeycomb; shown here is a section of the inside surface of the seal, against which the blades sweep as the rotor turns. **TURBO-ROCKET GUIDE-VANE** assembly is brazed without distortion using 300-series stainless alloys. **POWER TAKEOFF HOUSING** for jet engine is brazed in two subassemblies, each containing many cast and/or machined parts; material is low-alloy steel.

Similar information must be collected on the brazing alloys, particularly when used with various base metals. Vendor literature is useful, though the other sources listed above usually prove more fruitful. If data cannot be found, have simulated sections of the assembly brazed from several material combinations and tested to develop design data. At this point, you will be able to reduce your choices to two or three most likely combinations of base metal and brazing alloy.

Step 3: Design the joint. Joint clearance is the major factor here. For maximum strength, always design to the smallest tolerance that can be produced at the mating surfaces at the brazing temperature. Producibility is important because obviously a clearance that cannot be manufactured is useless. Brazing temperature is important when the mating base materials are dissimilar or when the thickness of similar materials are radically different—enough to cause different expansion rates in the heating cycle. Aim for a clearance of 0.002 in. or less. Thickness of available brazing alloy shim stock or foil will fix this figure. Maximum permissible clearance for a high-strength joint is about 0.005 in. Wider clearances, for low-stressed joints, can be specified up to about 0.050 in. if special "wide-gap" brazing alloys are used.

Most joints utilize some form of lap construction for maximum strength. Keep the overlap equal to 3 times base metal thickness T. Since most test data on brazed joints is on the basis of 1T overlap, 3T can be considered a safety factor. This lap might be increased to perhaps 4T for very thin metals (below 0.015 in.) since some common additives to brazing filler metals tend to alloy considerably with the base metal. Boron, for example, added to nickel-base brazing alloys for its fluxing action, diffuses completely into thin materials, causing embrittlement.

Step 4: Select the combination of base metal and brazing alloy. This is based on the detailed stress calculations made in Step 3 on the two or three best candidates. Other factors to be weighed are: relative cost/lb, availability, and the metallurgical factors discussed earlier in this article. A second choice should be made in case unexpected difficulties arise.

Step 5: Write the specifications. It's not enough to simply specify the base metal and the brazing alloy. The specification should clearly cover three other factors: condition of the material before brazing, its surface finish, and the brazing cycle itself.

Annealing should be specified for all material that has been machined, heat treated, or cold worked. This precaution will minimize distortion and cracking.

All mill finishes and oxides caused by fabrication procedures must be removed, either by pickling, vapor blasting or mechanical cleaning. Sand blasting alone is not recommended.

Heating and cooling cycle should be selected based on the type and thickness of the base metal, not on the brazing alloy. Thin materials are always heated rapidly through the cycle; heavy materials are heated slowly to assure uniform temperatures, thus minimizing distortion; thick-to-thin configurations are geared to the heavy section, but considering the possibility of grain growth in the thin section if overexposed. Brazing temperature should be maintained within ±25 F of the temperature that will melt and flow the brazing alloy. This temperature difference must be allowed for in joint-clearance calculations. (Cooling should be as rapid as is consistent with reasonable temperature uniformity.)

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, NY.

EDITOR'S NOTE: Recent articles on high-temperature materials, how to fabricate and design with them, include the following:

Electron Beam Welds in Vacuum, July 18 '60, p 70—Describes a new and sophisticated way to join most of the difficult-to-weld, high-temperature metals like tungsten and molybdenum.

Aluminized and Chromized Coatings Change Steel Properties, June 27 '60, p 31—These two important commercial methods for protecting steel differ in their effect on mechanical properties, as shown in latest data from Great Britain.

Forming Beryllium Sheet, June 20 '60, p 72—Beryllium excels other high-temperature materials in strength-to-weight ratio above 1100 F. Article gives latest rules on fabrication.

Metal Fiber Composites for High-temperature Static Seals, May 30 '60, p 57—Impregnating a metal felt with a compatible soft metal gives an unusual material that will seal 5000-psi air at 1000 F. Article reports latest developments.

Best Spring Material for High Temperatures, Jan 18 '60, p 44—Article surveys alloys for service above 400 F, shows how to select among them, and how to process them for better performance.

High-temperature Reinforced Plastics, Nov 23 '59, p 58—What space-age testing is telling us about the fundamental behavior of reinforced plastics at ultrahigh temperatures.

The Refractory Metals, May 25 '59, p 43—Although high melting points are common to the four so-called refractory metals—columbium, tantalum, tungsten, and molybdenum—there are important property differences that influence fabrication.

This Test for Oxidation Resistance, Apr 27 '59, p 48—New technique based on subsurface inspection gives clues to alloy performance at air temperatures up to 2200 F.

Carpet Plotting—A New Way to Display High-temperature Materials Data, Jan 5 '59, p 60—Old way needs two sets of curves to show interaction of three variables—stress, strain and temperature. New way speeds design by plotting everything on one sheet.

One Temperature for Successive Brazes, Dec 8 '58, p 84—How tight production control and special brazing alloys allow multiple brazes without reducing operating temperature of the final assembly.

Plasma-arc Plating, Dec 8 '58, p 104—With working temperatures above 20,000 F, the plasma-arc torch can melt any metal or ceramic you want to deposit, and is now shaping production parts from balky metals like tungsten and molybdenum.

New Superalloy Bids for Hot Jobs, July 21 '58, p 76—Rene 41 claims superiority in the 1200 to 1400-F range. Article gives facts and figures comparing it with other high-temperature alloys.

High-temperature Properties of Gray Iron Castings, Jan 20 '58, p 58—Article presents latest data showing performance of a workhorse material at elevated temperatures, and area where property information has been hard to find.

Which Coating at High Temperature? Jan 20 '58, p 61—Which coating types are best for corrosion resistance, erosion resistance, and compatibility with the base metal? Article gives the guideposts.

how to write

STANDARD OPERATING PROCEDURES

Individualists may cringe at the thought, but written instructions are essential to any large organization. They ensure that all those repetitive tasks—from preparing reports to ordering paper clips—will be done with minimum time and effort. Here are some tips on when to use them, how to prepare them, and how to get them approved.

D P SIMONTON, *manager, Design Support Service*
West Coast Missile and Surface Radar Div
Radio Corporation of America

The red tape in large industrial firms appalls most of us. What engineering manager has not asked himself at some time, "Why can't I take a couple of my best people, move our desks into my cellar and get this job done right—in one-fifth the time and at one-tenth the cost?" Of course, this solution is impractical—most of today's projects are far too vast for such a small group to handle without the support of a large organization. And large organizations mean reams of paperwork, directives from top management to middle management, orders from middle management to lower management and memos up and down the line.

Engineering procedures are inevitable. Though issued only occasionally, the stack of procedures grows quickly from a small sheaf of papers to bound volumes detailing standard methods for every phase of operation—procedures for filling out time cards, routing periodicals, filling out requisitions, purchasing test equipment, assembling equipment . . . even a procedure describing standard methods for procedures. Most of these are prepared by engineers—chief engineers, project engineers, drafting supervisors. Most are ignored or fail to get the attention they deserve because they are hastily prepared, poorly organized, easily misinterpreted, or too far removed from the problem at hand. But by following a few simple rules, you can write procedures that avoid the pitfalls that plague most communications issued by engineering departments.

Remember, procedures should help, not hinder. Though standard ways of doing things may seem to stifle a person's individuality, (particularly among independent people like engineers) the constrictions of a standardized procedure are a justifiable annoyance. Without them, there would be anarchy. Everyone would do things his own way and there would be more waste and inefficiency than is now caused by the troublesome paperwork. Standardized operations are based on the premise that there are several "right" ways to do a job, but only one "same" way—and that "same" way should be used in all the noncreative aspects of the job. The danger is that the paperwork will smother the organization rather than making it breathe freely.

Be brief—it saves time all around. Whenever possible, make a chart. A 17-page document may cover a problem like a blanket, settle every argument which could arise and stand as a literary monument; but nobody will read it. Therefore, hit only the high points and have some unofficial policy ready for special situations.

Don't refer to other procedures. Documents that simply modify previous policy without restating that policy (particularly when it has originated in other organizations) are sure to be ignored. An instruction that stands on its own will be made law out of sheer gratitude.

Organize coherently, assign numbers and index codes. Too frequently, managers fly into a rage and issue a procedure which is not a procedure at all, but a fragmentary whim of the moment. Here's a common pattern—Directive 12 says who is to perform each of a number of tasks; Directive 27 states what date one of these tasks (plus another no one has heard of) is to be performed; Directive 43 says: be sure to do it—or else; and Directive 74 rescinds the whole sordid business. A better approach is to issue Directive 12, 12A, 12B and 12C (each superseding its predecessor). If you can't afford the time to think it

through thoroughly, don't write it. But if you have to add information, don't simply modify—rewrite completely.

Limit procedures to routine, repeated operations. The installation of a screw on the production line is a legitimate topic; it can be standardized by a procedure based on a detailed time-and-motion study. But the one-shot design of a complex mechanism is a matter for individual thought and should never be shackled by the restriction of a standard method.

Concentrate on dispersed rather than centralized activities. The method of filling out a particular form at many dispersed locations should be standardized, but the exact method of processing this form at one particular check point should be left flexible and unrestricted. Repetitious activities at the local level find their own routine without a formal, officially published standard. The operation can be policed locally and need not concern other people.

Consider the reader. If the procedure is for engineers, it should be leveled at college graduates. Even more important, it should be aimed chiefly at key people who may be new to the organization. Once a procedure has been drafted, go back to its beginning, assume zero previous exposure to the subject, and read it with deliberate ignorance. If it can still be understood under these conditions it has a chance of success. But it is easy to assume "I know what it means, everybody else should too."

Be simple and direct. Forget the stilted language, the fancy words that prove how smart you are. Tedious, long-winded, Corinthian prose is one of the most serious faults of technical writing. You're an engineer, not a professional writer, so skip the long sentences and profound verbiage. Don't be passive and wishy-washy. Such phrases as "plans should be coordinated" are not compelling—either tell him to do it or forget the whole thing.

Avoid cryptic abbreviations. The "Army way" may be brief and conserving of paper, but such code systems have no place in company communications. Despite this, "alphabet soup" is as prevalent in private industry as it is in the Government—perhaps even more so. If you have to use an abbreviation, define it at the beginning. Instead of "c/o," write "c/o (change order)" the first time.

Don't let a committee do the writing. Let one individual sit down with pencil and paper, some knowledge of the subject and write. If the subject is controversial, a draft should be distributed for comments. These comments should be prompt and conclusive. Undue pride of authorship must die young in the writer of procedures. Somebody else can usually improve what has been written. But too much rewrite can reduce its impact. A procedure that has suffered through a dozen hard-fought drafts will clearly show the drudgery and frustration of its sponsor. Fresh, crisp procedures have to happen swiftly.

Minimize the number of approval signatures. I have seen a procedure with 16 signatures . . . and some individuals still refused to follow it because "My boss didn't sign it." I have written and signed a procedure and then had to wait three weeks for another manager to sign it. One approach to this problem, in a large organization, is to establish a small committee consisting of the staff assistant to each manager. Their function is to obtain prompt local comments on procedure drafts and, to obtain quick signatures when the final procedure comes around for approval. (If comments are scarce during the draft phase, they will be plentiful enough after issuance!)

Devious and complicated routing and approval cycles can cripple a procedure (or an organization). A long series of approvals on a routine piece of paperwork does not assure high-quality paperwork. Quite the opposite. The interest and responsibility implicit in any one signature is diluted to the point of meaninglessness. Also, with a lengthy approval cycle individual signers may feel they must speed the draft on its way, and thus give it only a hasty reading. There is a simple and effective way to cut down on the number of signers: Persons with only secondary interest should be put on distribution list rather than on the approval list. If these secondary persons object to the document, they can take veto action after issuance. In the words of the redoubtable Dr Samuel Johnson, "Nothing worthwhile will ever be accomplished if all possible objections must first be overcome."

Keep the distribution list short. "Blizzard issuance" is a menace to any organization. Administrators often feel that "To assure that no one can ever be left off a distribution, always send everything to everybody." The result of this policy is that everybody gets so much mail that, effectively, nobody receives anything. Although "paper is cheap" this cost is only a minor part of the over-all cost of carrying, in-boxing, reading, out-boxing, sorting and filing of a piece of useless paper. No matter how worthless it is, most people will try to read it and file it; the printed word commands awed veneration. Therefore, distribution lists should be ruthlessly pruned periodically to ensure that paperwork reaches only people who really need it, and nobody else. If possible, use carbons in place of hectographed copies. The reproduction process adds time, risks loss or damage of the master and encourages loading the files with needless material.

A procedure that delays the job, costs more, makes people angry and doesn't accomplish anything should be replaced or eliminated. No procedure should be followed merely because it is "in the book" or because "we have always done it that way."

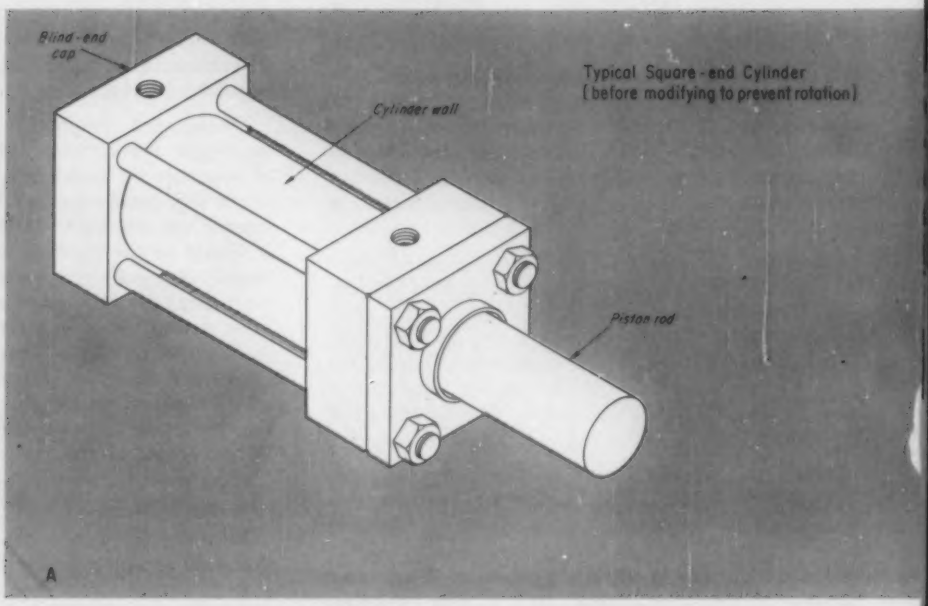
Procedures have to evolve with changing conditions; they are not sealed revelations. They have to be policed to ensure that they are being honestly tried and then policed again to ensure that they are performing their intended purpose. A procedure is a management tool that requires maintenance, repair and occasional replacement.

EDITOR'S NOTE: Engineering communication is critical problem these days. The following three articles have been reprinted in a single booklet to be available this week. You may obtain copies at $1 each from Readers Service Manager, Product Engineering, 330 West 42nd St, NY 36.

Five Steps to Faster Reading, Jan 5 through Feb 9 '59. A series of six articles that offer tips on how to improve your reading speed, and tests that check your progress.

8 Steps to Better Engineering Writing, Sep 7 through Oct 9 '59. A short but thorough analysis of engineering writing and recommendations telling how you can improve yours.

7 Steps to Better Oral Reporting, Jan 11 through Feb 22 '60. How to prepare and deliver your speech and how to chair a committee.



ten ways to . . .

PREVENT PISTON ROD ROTATION

Here's a quick review of the advantages and disadvantages of the common methods of preventing piston rod rotation. Author includes discussion of his invention—the V-groove ball guide—which promises to overcome some limitations of antirotation mechanisms.

DAN ROWAN, *president*
Titan Industrial Products
Newark, NJ

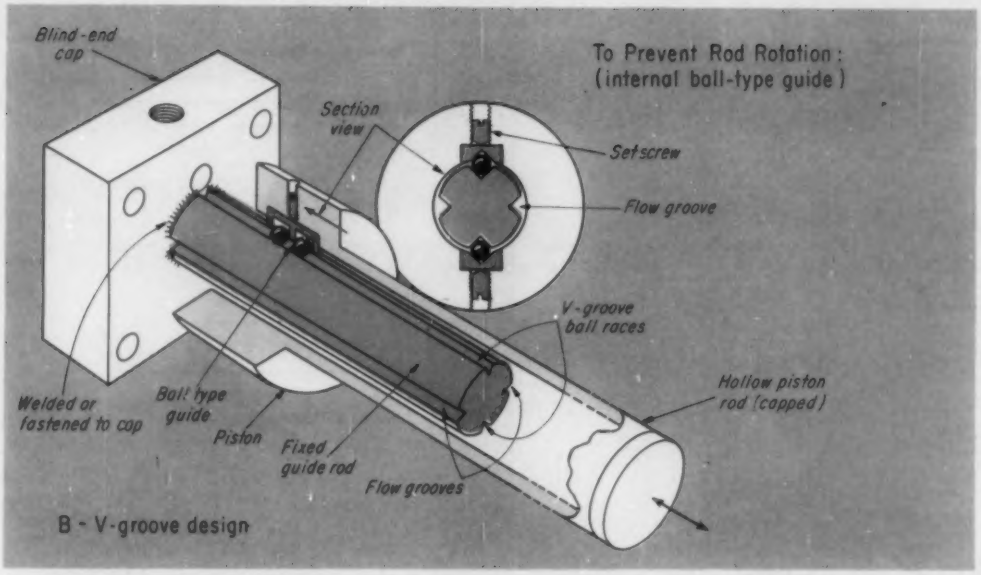
Nonrotating hydraulic or pneumatic pistons are needed when the part being pushed must mate with another in perfect registry. Two typical examples are: hydraulic presses that bring together mating halves of a die set, and packaging machines that must press parts into position or apply labels.

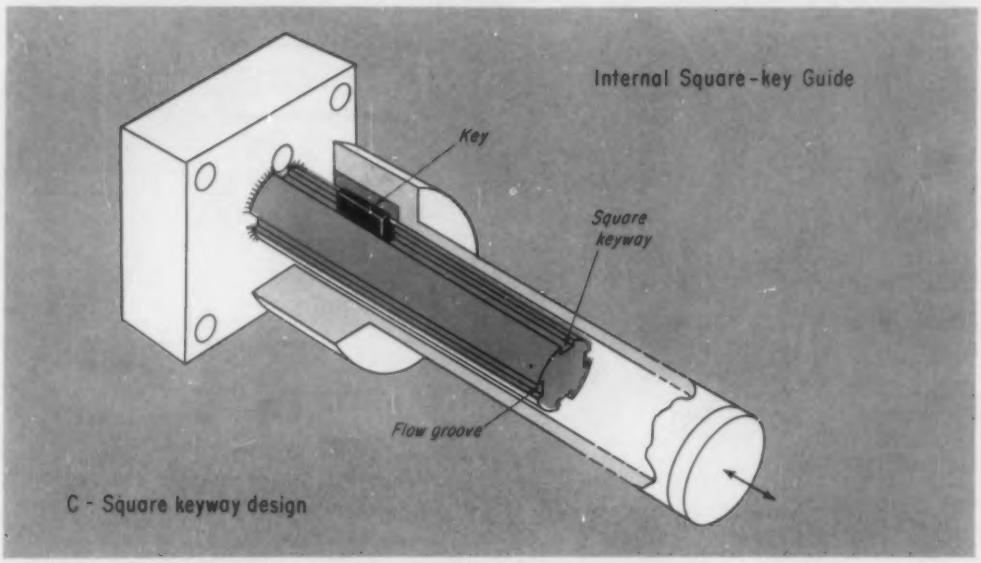
Ideally, the antirotation device should be inside the cylinder where it takes up no extra space (see sketches on facing page). Normally, however, external devices are used instead because they are fairly simple to build and adjust, and can be applied to standard cylinders. Experience with internal devices has been limited, and in many cases unfavorable. But one new internal technique–the V-groove ball guide–promises to overcome many of the objections. It will not cost more than the external devices, and it is more compact and retains all of the cylinder's capabilities. This device is shown in sketch B on the facing page as part of this review of the common (and unusual) internal and external methods of preventing piston rod rotation.

Guides Inside Cylinder

Fixed guide rod inside hollow piston rod prevents rotation in systems shown in the pair of sketches, *B* and *C*. Grooves in fixed rods are tracks for balls or keys. Both designs look basically the same, except that *C* (from a previous patent) has square keys in square grooves instead of balls in V-groove (*B*).

Both designs are double-acting (piston can be pressurized to move in either direction), and will work at high or low pressures with air or oil. Hollow piston rod—can be made from standard tubing—does not appreciably reduce column strength. Full area of piston is effective on advancing stroke (rod extending) because fluid pressurizes hollow rod. Cylinder has same mounting dimensions as standard





types, and uses standard seals. For higher torques, more keyway grooves can be added to the fixed guide.

V-groove design *B*—essentially a keyway with spherical instead of square keys—has greater tolerance than keyway design *C* for contaminants (grit, lint) because the groove bottom gives dirt a place to go. And balls are less likely than key to wear because they tend to rotate during piston travel, evenly distributing the points of wear. Note: balls will slide inside retainer and do not have rolling action of ballbearings. If balls or V-groove should wear, play can be taken up by first removing piston (preferably during planned seal and packing change) and tightening setscrew.

Neither design *B* nor design *C* is in commercial production by any manufacturers. Design *C* has relatively poor tolerance to dirt. Design *B*—having less of a dirt problem —has better possibilities, and future production is planned.

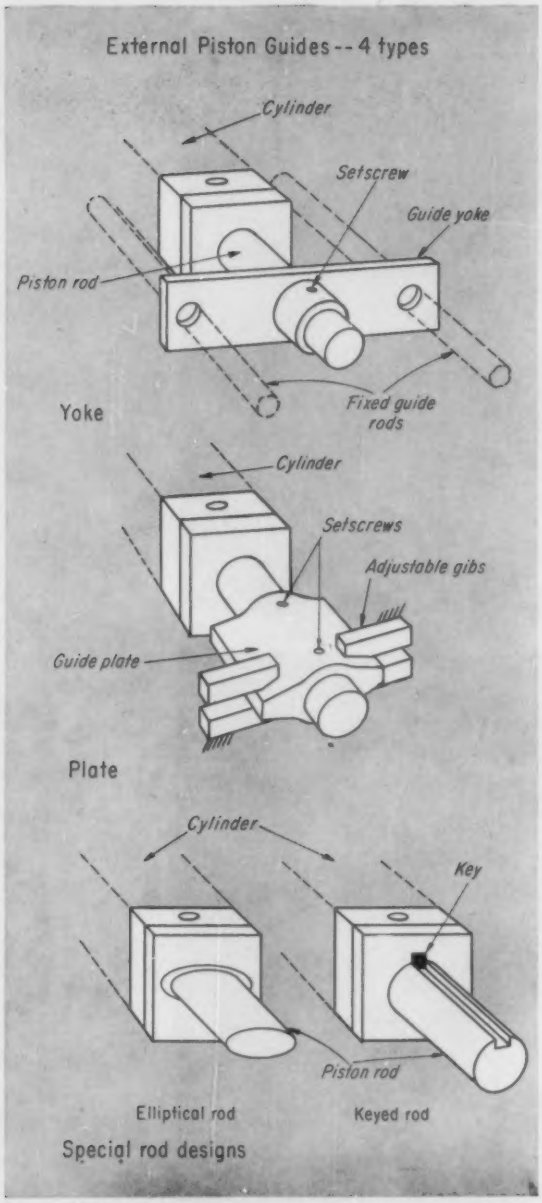
Four fixed guide rods. In this design (p 50) rods fit through close-clearance holes in the piston. Seals around the rods are needed to prevent leakage through the holes in the piston.

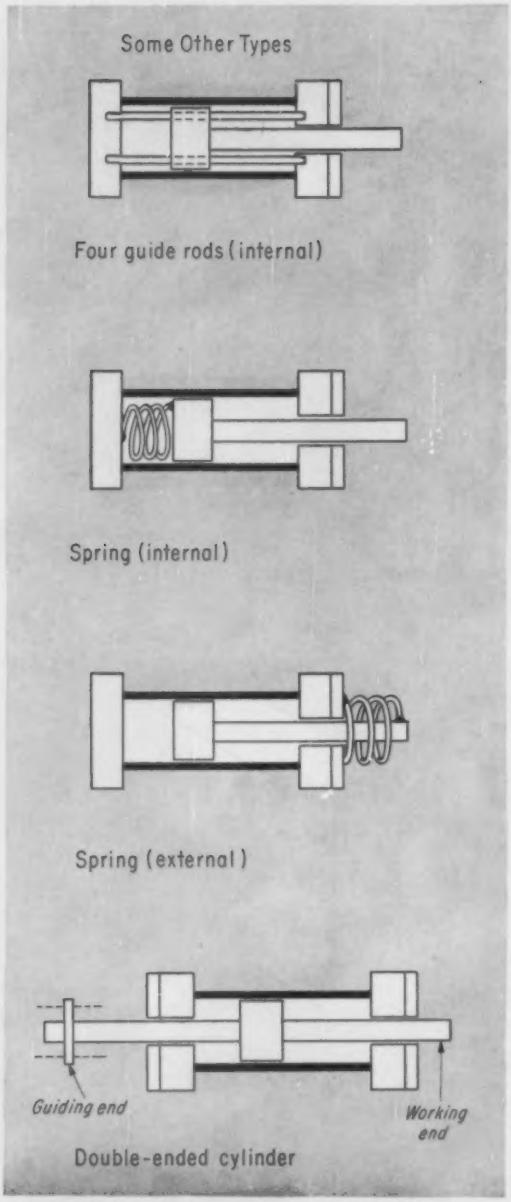
Spring connecting piston and end cap. Piston will have little torque resistance. Also, the spring gradient will affect the force-pressure-displacement relationship of the cylinder.

External Piston Guides

Guide-yoke design (p 50) and its variations are very common. They can be adapted to any cylinder, and are easily made. Bulk is a disadvantage, as is need for special parts and labor to build adaptor.

Guide-plate type is similar to guide yoke, but is readily





adjustable and can hold piston rod in close registry—useful in precision applications such as forcing male and female dies together under high pressure. For increased accuracy and torque resistance, more gibs can be added.

Noncircular piston rods—elliptical or keyed—prevent rotation, but are difficult to seal. Elliptical version requires elliptical hole and expensive packing. Rod wears on minor radius of ellipse, due to concentration of stress when torque is applied. Keyed rod, round except for keyway, cannot be sealed in any reasonable way, and is limited to single-acting applications that exhaust at rod end.

The other designs sketched on this page are also possible: four-guide-rods (internal); internal spring; and external spring. They are all compact and will solve special problems. If your application problem cannot be solved with any of the methods, and space at working end of cylinder is cramped, perhaps the final answer is a double-ended cylinder which can have any size or shape guide—out of the way at the nonworking end.

EDITOR'S NOTE: Cylinder design and selection have been subject of these previous Product Engineering articles:

For Push or Pull, Is Compressed Air Your Answer? Oct 14 '57, p 72, describes safety circuits, cushioning devices, and flow control for cylinders.

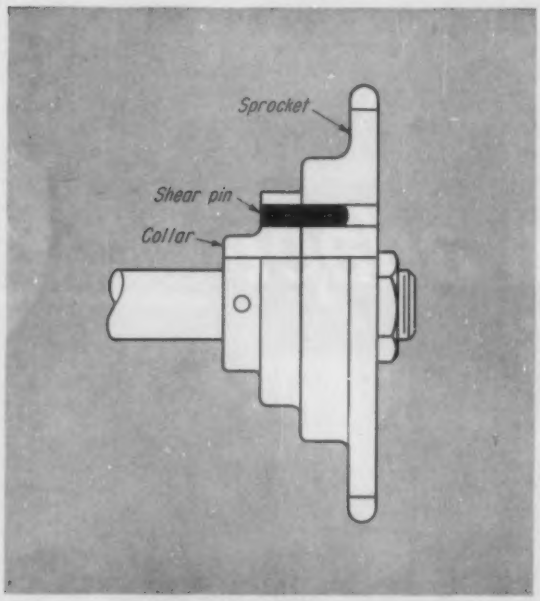
When Pistons Need Brakes, Feb 3 '58, p 56, describes action of damped and undamped hydraulic cylinders, giving 10 different methods for braking—including sinusoidal flow-control mechanism, open binary piston (dashpot) and simple communicating orifices.

Buckling in Hydraulic Tubing, May 11 '59, p 71, summarizes column-formula and cylinder-buckling data and applies it to high-pressure hydraulic tubing.

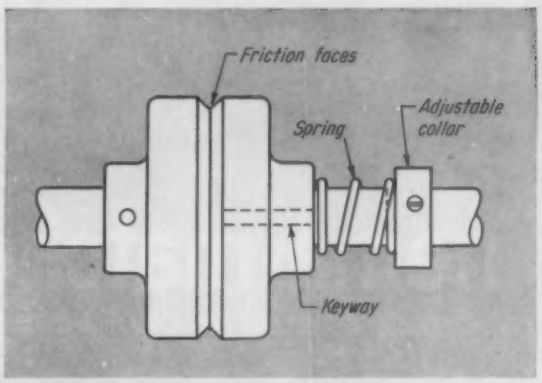
6 ways to PREVENT OVERLOADING

These "safety valves" give way if machinery jams, thus preventing serious damage. More devices will appear in a future issue.

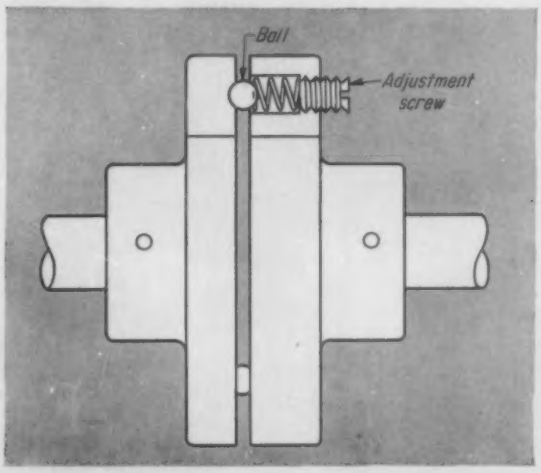
PETER C NOY, *technical representative,*
Nicromatic Ltd
Toronto, Ont



1
SHEAR PIN is simple to design and reliable in service. However, after an overload, replacing the pin takes a relatively long time; and new pins aren't always available.



2
FRICTION CLUTCH. Adjustable spring tension that holds the two friction surfaces together sets overload limit. As soon as overload is removed the clutch reengages. One drawback is that a slipping clutch can destroy itself if unnoticed.



3
MECHANICAL KEYS. Spring holds ball in dimple in opposite face until overload forces the ball out. Once slip begins, wear is rapid, so device is poor when overload is common.

continued on page 53

ONE pump becomes MANY . . . saving you pump dollars . . . giving you a wide range of clear water, non-clog and other liquid-handling modifications . . . when you standardize your pumping operations with Fairbanks, Morse ADAPT-*ABLE* pumps.

F-M ADAPT-*ABLES* consist of a pump frame and simple adapter to which can be attached a wide variety of F-M hydraulic ends with enclosed, semi-open or non-clog impellers. Conversion is easy . . . inexpensive, too.

F-M ADAPT-*ABLES are "NEMA-Matched"*: pump mounting dimensions are standardized with similar dimensions of Nema-driving motors. Gone is the need for make-shift height-adjusting blocks and odd-bore couplings!

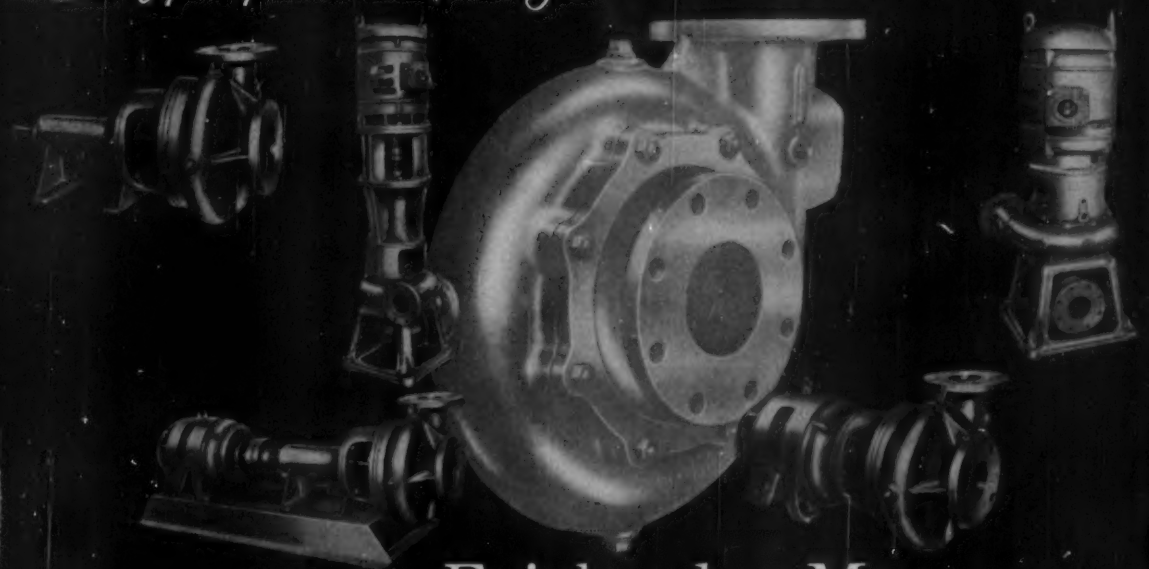
The ADAPT-*ABLE* design means that the most economical frame size may be selected to match the motor horsepower requirements of the pumping job.

And there are other advantages: choice of mechanical seals or conventional stuffing boxes with easy field change-over from one to the other . . . interchangeable bearings for pumps and motors. For special liquid handling problems, hydraulic ends can be specially alloyed to fit the needs: we've been solving such problems for generations.

Regardless of *what* liquids you pump . . . or *where* . . . Fairbanks, Morse builds pumps and *matching* power units for *your* use . . . in a greater range of sizes, types and capacities than *anyone, anywhere*. Start SAVING pump and motor dollars by putting F-M's vast hydraulic experience to work in your plants, process lines and products . . . now!

"nema-matched" *adapt-ables*

. . . a lot of pumps in ONE package!

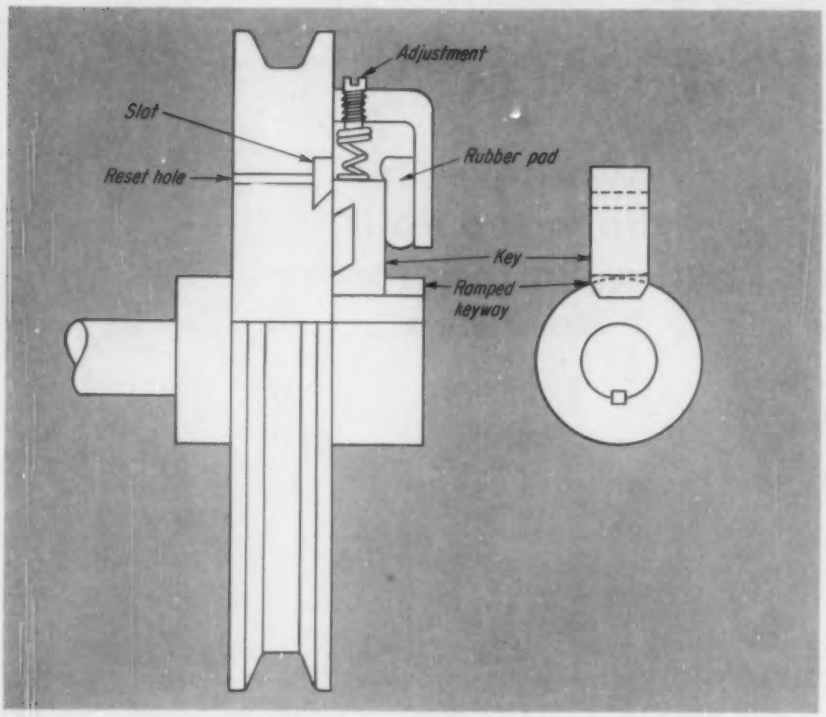


Fairbanks, Morse

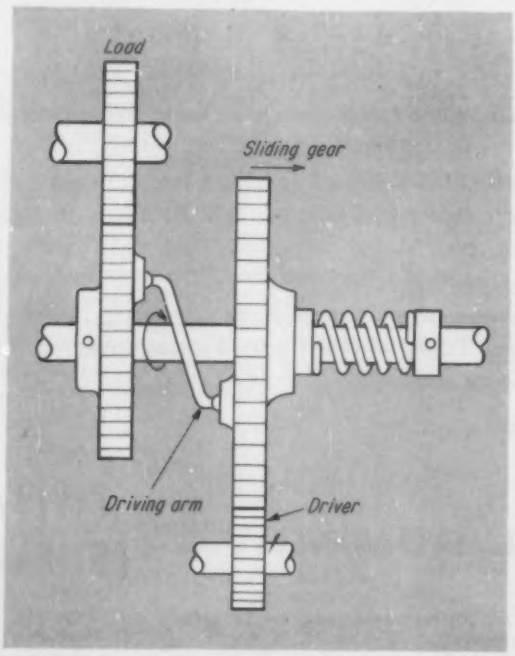
THE PROUDEST NAME IN PUMPS

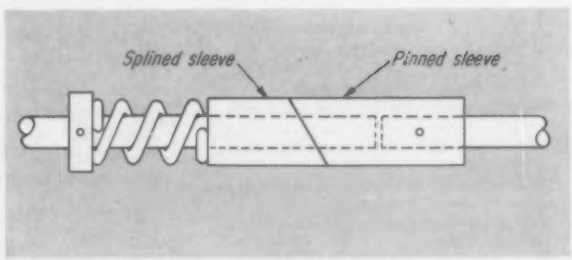
Pump and Hydraulic Division • Kansas City, Kansas

A MAJOR INDUSTRIAL COMPONENT OF **FAIRBANKS WHITNEY CORPORATION**



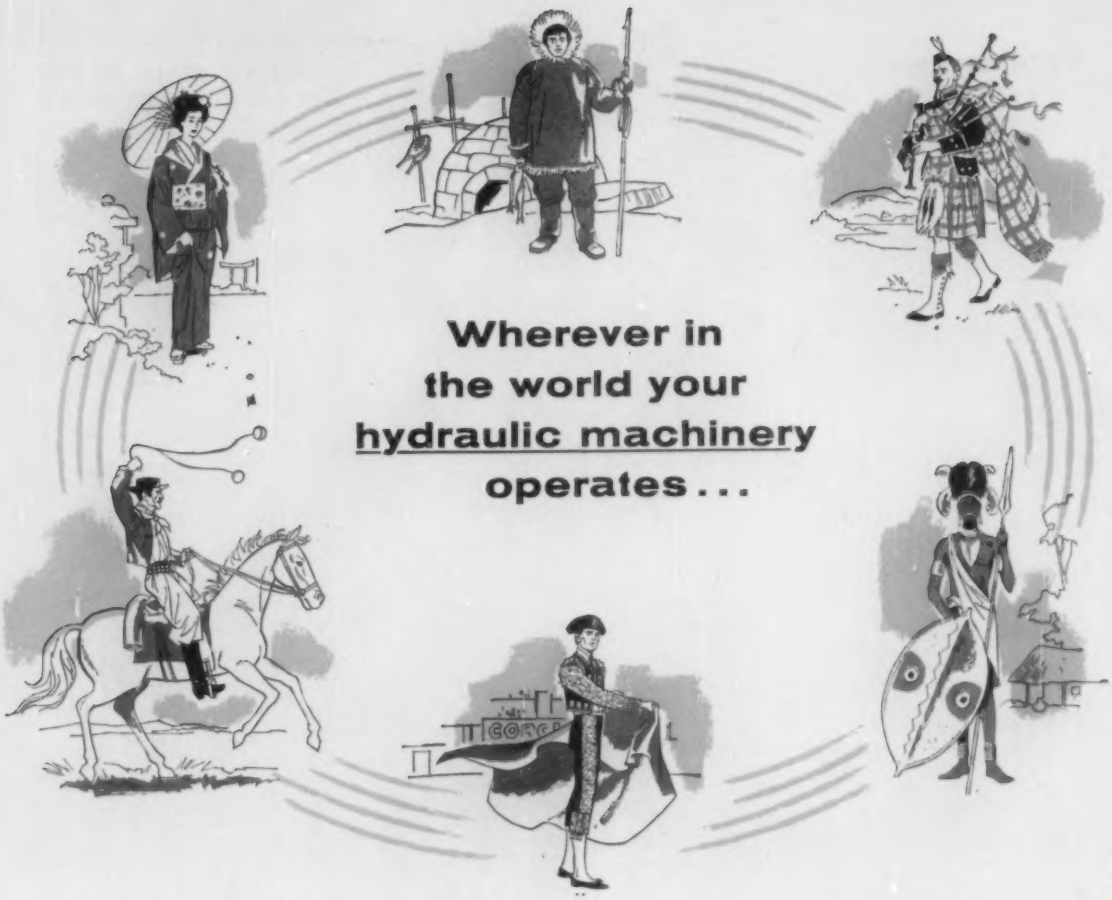
4
RETRACTING KEY. Ramped sides of keyway force key outward against adjustabe spring. As key moves outward, a rubber pad—or another spring—forces the key into a slot in the sheave. This holds the key out of engagement and prevents wear. To reset, push key out of slot by using hole in sheave.





5
ANGLE-CUT CYLINDER. With just one tooth, this is a simplified version of the jaw clutch. Spring tension sets load limit.

6
DISENGAGING GEARS. Axial forces of spring and driving arm balance. Overload overcomes spring force to slide gears out of engagement. Gears can strip once overloading is removed, unless a stop holds gears out of engagement.



Wherever in the world your hydraulic machinery operates . . .

Shell Tellus Oil is there

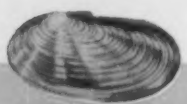
Other outstanding Shell Industrial Lubricants available world-wide

- **Shell Rimula Oils** — for heavy-duty diesel engines
- **Shell Talona R Oil 40**—anti-wear crankcase oil for diesel locomotives
- **Shell Alvania Grease** — multi-purpose industrial grease
- **Shell Turbo Oils**—for utility, industrial and marine turbines
- **Shell Dromus Oils**—soluble cutting oils for high-production metalworking
- **Shell Macoma Oils** — for extreme pressure industrial gear lubrication
- **Shell Voluta Oils** — for high-speed quenching with maximum stability

Around the world, Shell Tellus Oil is available—under the same brand name and providing the same performance that your domestic customers rely upon.

Tellus® Oil is top-rated as both a lubricant and control fluid for complex hydraulic systems. Its ability to combat oxidation, rust, sludge formation, wear and foaming has earned it world-wide popularity.

No matter where your hydraulic machinery is shipped, make Shell Tellus Oil your standard recommendation. Write for complete information.



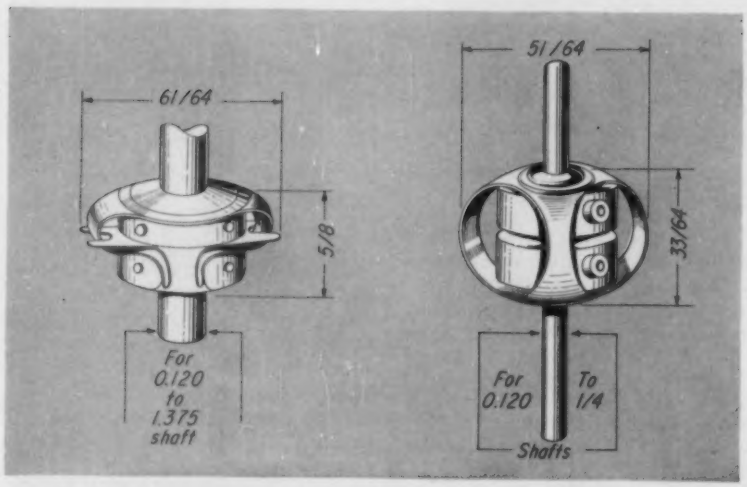
AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the Cultellus costatus.

SHELL OIL COMPANY

50 WEST 50TH STREET.....NEW YORK 20, N. Y.
100 BUSH STREET.....SAN FRANCISCO 6, CALIFORNIA
IN CANADA: SHELL OIL COMPANY OF CANADA, LIMITED
505 UNIVERSITY AVENUE.....TORONTO 2, ONTARIO

SHELL

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Miniature, flexible four-way coupling . . .
allows up to 5° angular, 0.020-in. parallel misalignment as well as up to 0.125-in. end float. Approximately ¼-in. long and able to accommodate shafts up to ⅜ in. dia, couplings are available made of beryllium copper, 17-7 Ph stainless, 18-8 stainless, brass. Torque ratings range from 6 to 150 in.-oz, depending on material and design. From $2.29. Standard items from stock, others 2 wk. **Davale Coupling Co., 147 N Ave 18, Los Angeles 31, Calif.**

Circle 300 on Reader Service Card

Silicone and silicone-ceramic . . .
coatings are for application to metals exposed to temperatures up to 1400 F. Available in a variety of colors, 10 different formulations are made, for selection based on temperature, corrosive conditions and other factors. From $3 to $38.90 gal, depending on formulation. Delivery, 1-4 wk. **Dampney Co, Hyde Park, Boston 36.**

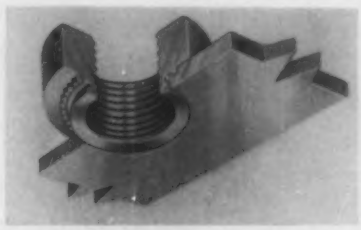
Circle 301 on Reader Service Card

Speed-reducers and gearheads . . .
with whole-number ratios said to be accurate within 0.5%, are available in over 190 stock ratios—from 7:1 to 5950:1. Either opposite or direct rotation and lubricated for life. Output torque is 75 in.-oz, starting torque, 0.005 in.-oz. Backlash, 30 minutes, max. Shafts and gears are stainless, bearings are ABEC-7. From $88 to $78, depending on number of clusters. Available from stock. **Dynamic Gear Co Inc, Dixon Ave, Amityville, NY.**

Circle 302 on Reader Service Card

Irradiated polyolefin . . .
compounds have the ability to resume original configurations even after being forced into other shapes temporarily. Bombarding with gamma radiation is done after they have been formed or molded into desired end shape. Available in either electrically conductive or nonconductive states. Also said to possess superior mechanical properties. **Mimx Corp, 1515 Gardena Ave, Glendale, Calif.**

Circle 303 on Reader Service Card



Sheetmetal fastener . . .
is a press-in nut said to provide a liquid-tight seal. Tensile strength exceeds that of 200,000-psi bolt. Available in coarse or fine threads ranging in size from 4-40 NC to ½ in.-20 unf and can be installed by hammer, bench vise or arbor press. Made in AISI B1113 steel as well as other alloys. Prices are competitive; popular sizes from stock. **Hi-shear Rivet Tool Co, 2600 W. 247 St, Torrance, Calif.**

Circle 304 on Reader Service Card

Color-coated stainless steel
is produced in coil or sheet form up to 48 in. wide in all popular gages, and can be sheared, bent, formed and drawn without damaging coating. Also available embossed or textured. **Washington Steel Corp, Washington, Penna.**

Circle 305 on Reader Service Card

Maximum reading meter . . .
combining a meter-relay movement and special circuitry has a pointer that remains at highest signal received over any period of time until reset. Other pointer provides continuous signal readings, kicking maximum-reading pointer upscale whenever a new, higher signal is received. Available

in any of the standard sensitivity ranges. Less than $100, depending on sensitivity specified. Delivery 6 wk. **Assembly Products, Inc, Chesterland, Ohio.**

Circle 306 on Reader Service Card

Fhp gearmotor . . .

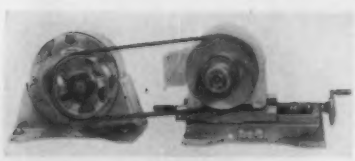
has rectangular field and toroidal field windings that are said to be capable of delivering $\frac{1}{10}$ hp continuous, $\frac{1}{4}$ hp intermittent, although over-all dimensions are only $1\frac{3}{8}$ x $2\frac{1}{4}$ x $4\frac{3}{8}$ in. Weight $1\frac{1}{4}$ lb. Illustrated model incorporates 3:1 reduction, approximately 22 in.-oz torque at $3\frac{1}{2}$ amp, 27 v dc. Available 90 to 120 days. Aircraft quality: $100 and up, depending on quantity. **Bendix Corp, Bendix-Pacific Div, 11600 Sherman Ways, N Hollywood, Calif.**

Circle 307 on Reader Service Card

Temperature detectors . . .

include: dual-element tip-sensitive unit for measuring same temperature at two different locations or for indicating and recording simultaneously; hermetically sealed high-temperature unit for up to 1500 F; miniature tip-sensitive unit $\frac{1}{4}$ x 0.278 in. dia; explosionproof unit, also hermetically sealed. **Instrument Div, Thomas A. Edison Industries, McGraw-Edison Co, West Orange, NJ.**

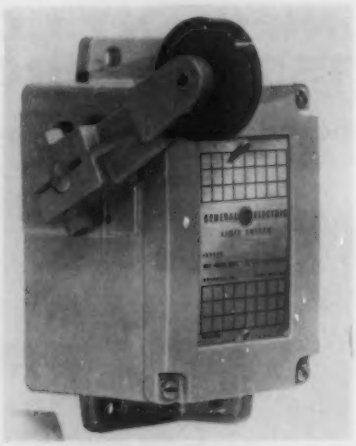
Circle 308 on Reader Service Card



Variable 3:1 speed drive . . .

provides driven shaft speeds of 431 to 24 rpm. Consists of standard variable-speed pulley, belt, and adjustable motor base and speed reducer. For use with $\frac{3}{4}$, 1 $1\frac{1}{2}$, 2 and 3 hp motors. **Boston Gear Works, Quincy 71, Mass.**

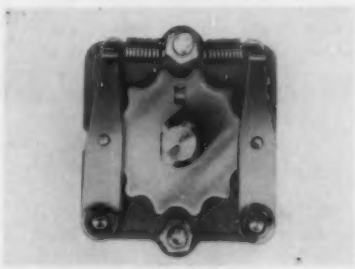
Circle 309 on Reader Service Card



Heavy-duty lever limit-switch

can be adjusted to provide more than 100 different contact-and-lever combinations with a screwdriver and wrench only —no extra parts are required. Available for either two- or four-circuit operation, NEMA Type 1, 3, 4, or 5 enclosures are available. Various types of levers can be used with this switch. **Industry Control Dept, General Electric Co, Schenectady 5, NY.**

Circle 310 on Reader Service Card



Rotary switch . . .

can have either fixed or adjustable stops, and torque is closely controlled in both directions by double spring-arm construction. Finishes available are commercial grade, 50-hr salt spray or complete stainless steel construction. Life test of 100,000 cycles through 12 switch positions developed no change in torque. Designed for 185 to 257 F. **Trolex Corp, sub CTS Corp, McHenry, Ill.**

Circle 311 on Reader Service Card

Explosionproof proximity switch . . .

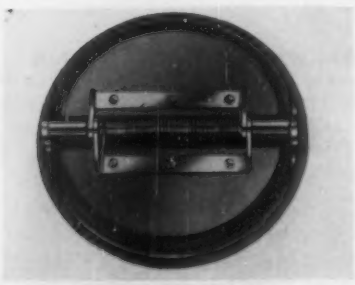
can be used to actuate counters, alarms or other mechanisms without actual physical contact with objects causing switch to operate. Rated 115 v, ac at 1 amp. Will operate if actuating object is within 2 in.; response time is 1 milisec, minimum. **Electro-Seal Corp, 946-A North Ave, Des Plaines, Ill.**

Circle 312 on Reader Service Card

Switch section . . .

based on etched circuits is said to pass all applicable MIL tests for insulation, breakdown, temperature and vibration. Suitable for motor-driven switches, a variety of contact combinations are possible. Cost ranges from two to six times price of conventional switch sections, depending on materials used and environmental requirements. **Electronics Div, Globe-Union Inc, E Keefe Ave, Milwaukee 1.**

Circle 313 on Reader Service Card



Split-flapper checkvalve . . .

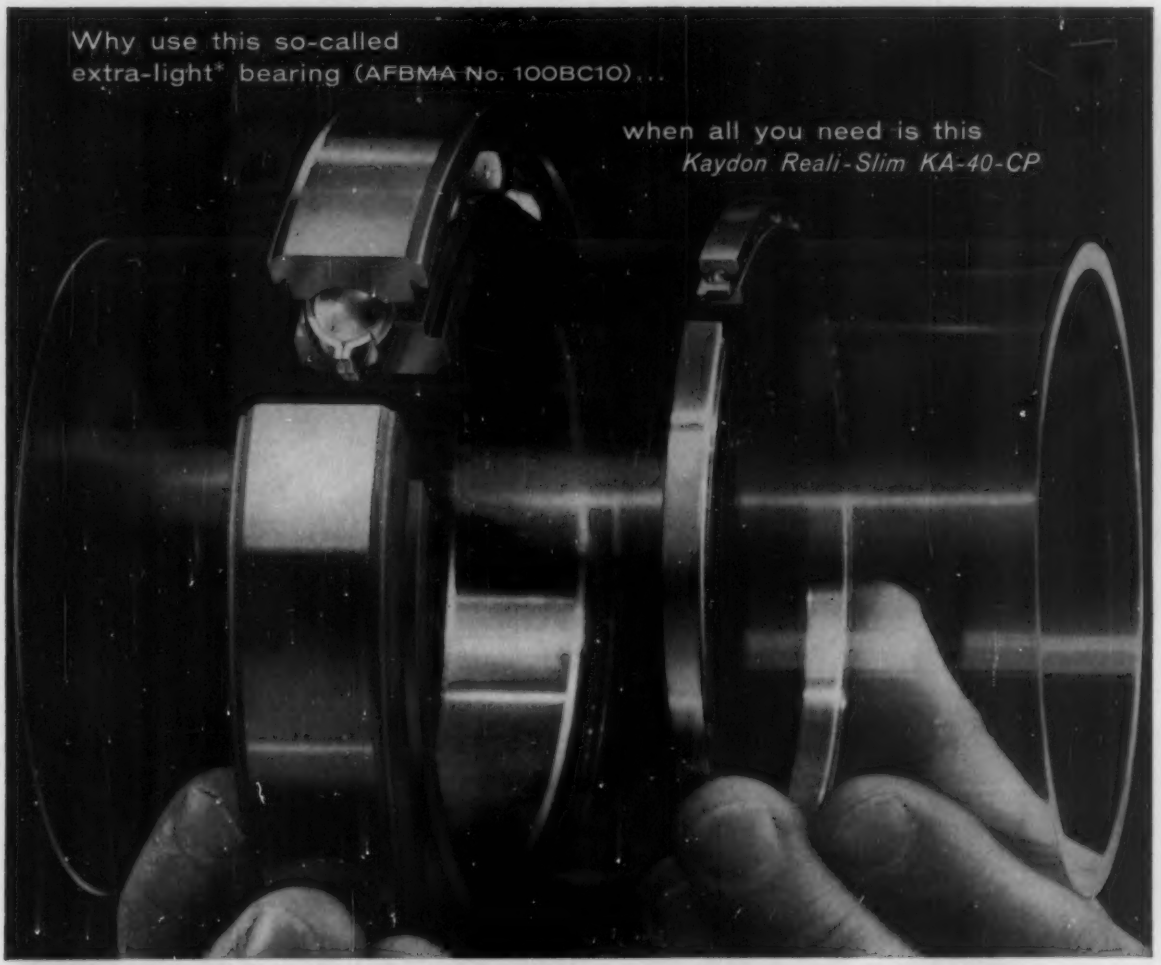
is spring-loaded and hinged in center to permit air or gas flow in one direction only. Will operate in temperatures of —65 F to 700 F. Internal leakage is 0.5 lb/min. at 368 psig and 700 F. Available in several sizes, from 1 to 4 in. **Barber-Colman Co, Rockford, Ill.**

Circle 314 on Reader Service Card

250 in.-oz synchronous motor

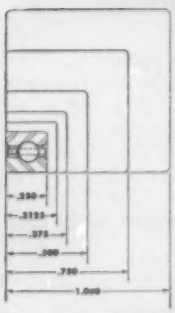
provides constant speed of 72 rpm and can be used for ac synchronous or dc step-

continued on page 58



News from Kaydon!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Up to 85% lighter, up to 70% narrower than the lightest of the "extra-lights"

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ¼" width and cross section. Result: new opportunity to save on cost, size, and weight . . . in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — ¼" to 1" width and cross section. Kaydon's volume production cuts prices as much as 76%, depending on size. Write for free, fact-filled "CP" bearing bulletin — with prices!

THE KAYDON ENGINEERING CORP.
MUSKEGON • MICHIGAN

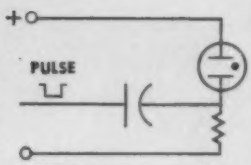
All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

K-160

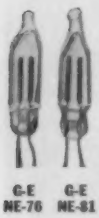
4 ways to use

General Electric Glow Lamps as Circuit Components

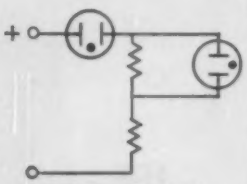
1. As a MEMORY DEVICE, because of the differential between starting and operating voltages. Both the General Electric NE-96 and NE-97 are well suited for switching circuits and counters where they can function as transfer elements and as indicators of state or sequence.



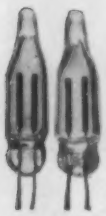
G-E Glow Lamp used in Memory Circuit



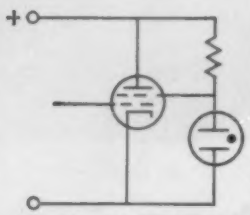
2. As a VOLTAGE INDICATOR, because of their critical starting voltage. The G-E NE-76 and the NE-81 are stabilized and selected for close tolerance on starting voltage. Both find use in gating circuits, logic matrices, switching circuits or as an indicator of input or output levels.



G-E Glow Lamps as Multiple Voltage Indicators

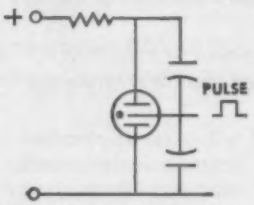


3. As a VOLTAGE REGULATOR, because of their constant operating voltage range. The General Electric NE-68 and its "first cousin", the G-E NE-80 (closer tolerance), function effectively wherever voltage regulation is required. (Glow Lamps for higher current applications are also available.)



G-E Glow Lamp used as a Voltage Regulator

4. As a TRIGGERED SWITCH. A low current signal applied to the trigger (third electrode) starts this lamp, permitting conductance of peak current surges up to 100 m.a. in the power circuit. It can be used in counting circuits or as a control device with photocells, thermostats or moisture sensors in trigger circuit.



G-E NE-77 in a Trigger Circuit

For more information, write for: Specification Sheet #3-092 "G-E Glow Lamps for Circuit Component Use". General Electric Co., Miniature Lamp Dept. M-021, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

ping operation. Will retain rated torque for any of 200 steps into which single revolution can be split. Input, 120 v, 40/70 cycles, single-phase, 0-6 amp max current (at 60 cps). Weight, 6½ lb. Superior Electric Co, Dept SS, Bristol, Conn.

Circle 315 on Reader Service Card

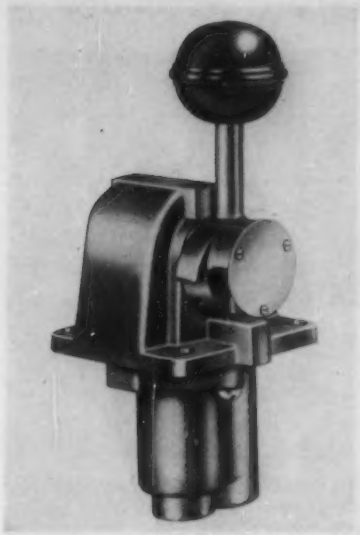
Cast iron footswitch . . . can be used for either momentary or maintained actuation (note button set in face of housing). Has 15-amp rating; price is $9. Delivery is usually from stock. Vemaline Products Co, Franklin Lakes, NJ.

Circle 316 on Reader Service Card

Temperature controller . . . of pyrometric type is available in 11 ranges, from 0-400 F to 0-300 F, as well as an environmental test-chamber range of —100 to 300 F. Alnor Instrument Co, Div Illinois Testing Laboratories Inc, 418 N LaSalle St, Chicago 10.

Circle 317 on Reader Service Card

Directional pneumatic valve . . . is for panel mounting and comes as a single-unit valve, normally closed or normally open for three-way operation, and as double units which provide three types of four-way operation. An all-purpose operating cam can be rotated to change operation from one function to another.



Made of die-cast zinc, with hardened sintered-steel cams. Suitable for 250 psi max air pressure and from —40 F to 200 F. Prices start at $18.60. Westinghouse Air Brake Co, Industrial Products Div, Wilmerding, Penna.

Circle 318 on Reader Service Card

Narrow pillow-block bearings designed for light- and medium-duty service, are constructed of rubber-impregnated fabric between metal shields; and are factory-lubricated for life. Available in range of shaft sizes from ½ to 1⅞ in. Hoover Ball Bearing Co, 5400 S State Road, Ann Arbor, Mich.

Circle 319 on Reader Service Card

Miniature heater . . . rated from 20 to 75 w for 6 to 115 v ac or dc has small opening through center for passing a fluid or wire to be heated (as high as 800 F). Price $9. Sorrels-Johnson Corp, 363 Rantoul St, Beverly, Mass.

Circle 320 on Reader Service Card

4-pole contact blocks . . . make up to 20-pole relay that stacks on solenoid frame, making it possible for contact-activating plungers in each block of stack to be operated. Blocks have standard configuration of a pair of normally open

continued on page 60

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD 66DD.

DUFF-NORTON COMPANY

Four Gateway Center • Pittsburgh 22, Pa.

COFFING HOIST DIVISION • Pittsburgh, Pa.

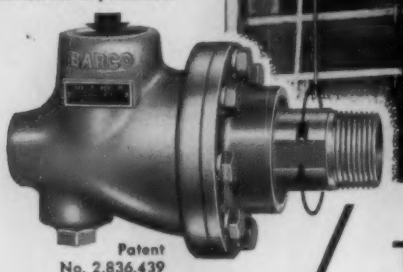
DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

OUTSTANDING PERFORMANCE

BARCO ROTARY JOINTS

Shown at the right is an installation of ¾" Barco Type C Rotary Joints on a 9" dia. calender roll stack. Every other roll is equipped to be steam heated and syphon drained at 125 p.s.i., 300°F. The rolls run at a paper speed of 1300 FPM, or approximately 450 RPM. The joints have been in service for many months with no difficulties experienced.



Patent No. 2,836,439

TYPE C

Single Flow or Syphon Flow

- **RESISTS SEAL RING BREAKAGE**—The spherical seal ring is under compression, not *tension*, loading. Self-adjusting for wear. Seal withstands shock loads and alternating hot and cold service.
- **WIDE SPACED BEARINGS**—Two, instead of one . . . increased bearing area. No lubrication required. Lowest friction.
- **200 P.S.I. STEAM RATING**—Heavy duty service at *no extra* cost. Eight sizes, ½" to 3".

HERE is another case (*above installation*) where an experienced user of rotary joints made comparative tests. Two other makes of joints were tried and Barco selected.

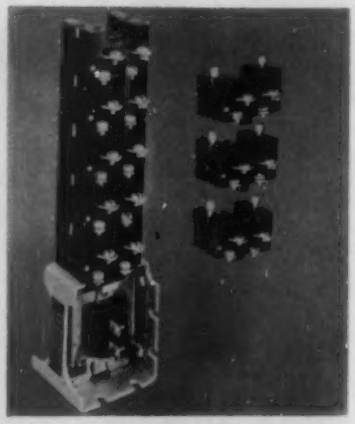
"*Last longer without maintenance!*" reports the user. When properly installed, Barco Joints easily withstand rugged service on paper calenders, machines, and other mill equipment.

Barco Type C Joints are available from LOCAL STOCKS throughout the country. Standard series joints handle all steam pressures to 200 psi—one basic style for all services, single flow or syphon flow. *Type CF offered for journal flange connections. ASK FOR INFORMATION.*

SEND FOR CATALOG 310

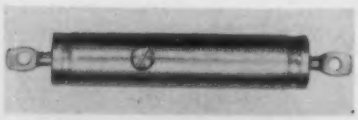
FOUNDED 1902 BARCO PRODUCTS BACKED BY EXPERIENCE

BARCO MANUFACTURING CO.
5271 Hough Street, Barrington, Illinois
The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Rotary Joints
In Canada: The Holden Co., Ltd., Montreal



and normally closed contacts on each side. Blocks are molded phenolic, 2 x 1¼ x 1½ in. Lake Shore Electric Corp, 205 Willis St, Bedford, Ohio.

Circle 321 on Reader Service Card

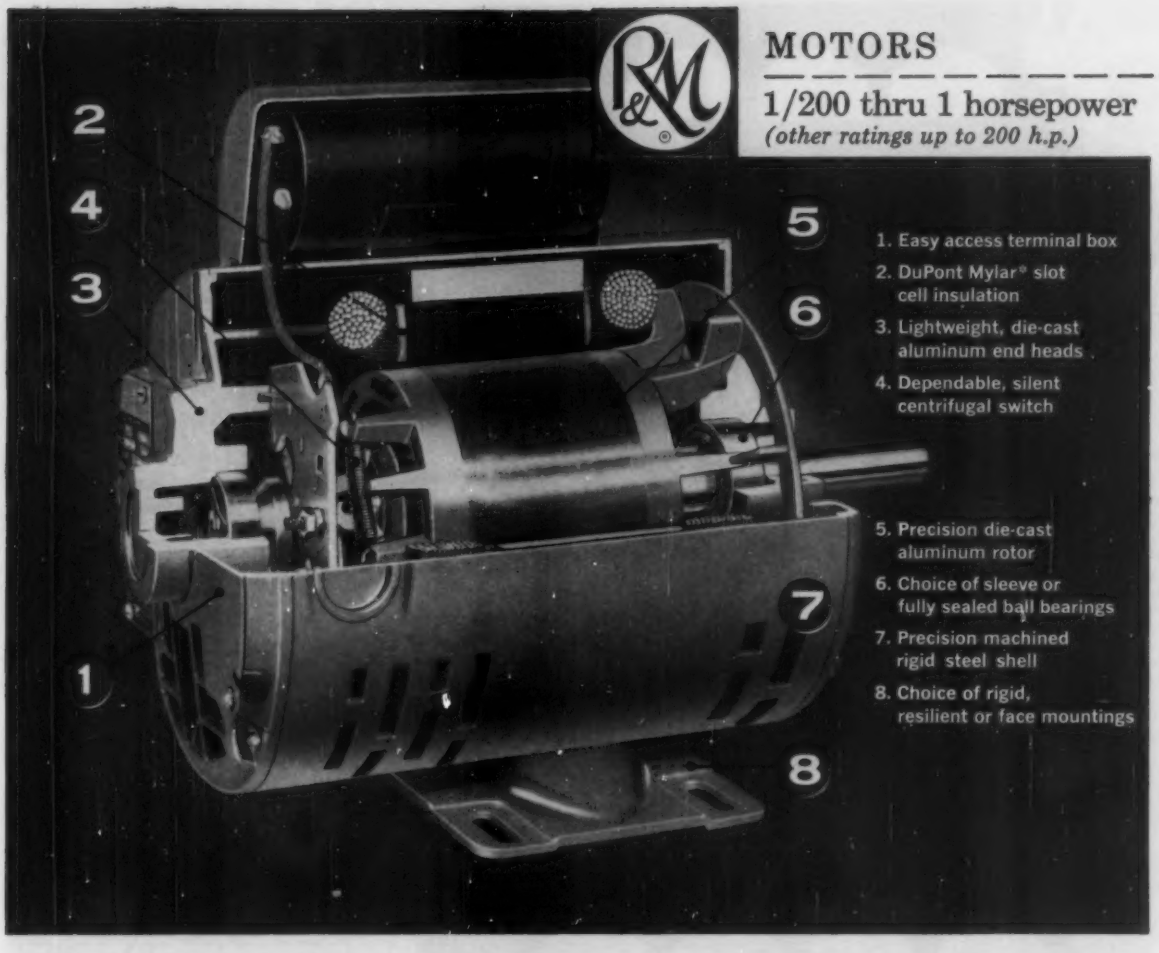


Insulated ¼-in. thermostat . . . can be factory-calibrated or adjusted in the field by means of an external screw to set desired actuating temperature. Screw can then be hermetically sealed. Ambient temperatures do not affect actuation point. Bimetal-actuated contact is powered by spring. Chatham Controls Co, 159 River Road, Chatham, NJ.

Circle 322 on Reader Service Card

Plug-in reset timer . . . designed primarily for flush mounting, can be removed and replaced from its permanently mounted case in 5 sec or less. Timer contains four separate and independent load contacts, two of which are instantaneous and may be considered and

continued on page 62


R&M
MOTORS
1/200 thru 1 horsepower
(other ratings up to 200 h.p.)
1. Easy access terminal box
2. DuPont Mylar® slot cell insulation
3. Lightweight, die-cast aluminum end heads
4. Dependable, silent centrifugal switch
5. Precision die-cast aluminum rotor
6. Choice of sleeve or fully sealed ball bearings
7. Precision machined rigid steel shell
8. Choice of rigid, resilient or face mountings

R & M Fractional Horsepower Motors are packed with *Competitive Advantages* for your product!

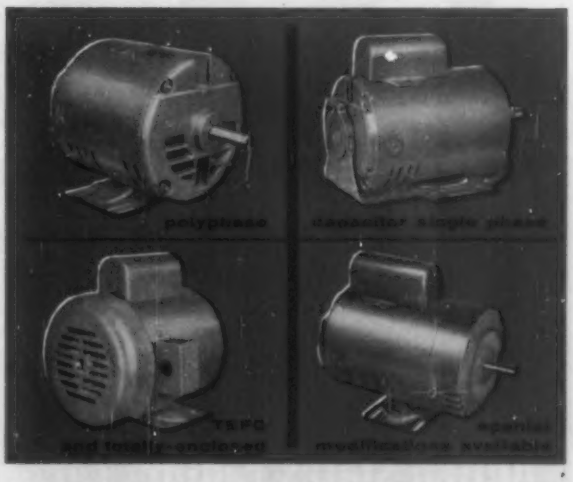
ROBBINS & MYERS "Model R" fractional HP motors, available in NEMA frames 56 and 48, are engineered and manufactured to give your product every possible competitive advantage so far as power is concerned. Each design detail results in superior performance and long trouble-free life, even under the severest operating conditions. They are smaller due to a more efficient ventilating system and lighter because of new applications of aluminum, steel and copper.

You have wider design versatility too, because they are available off-the-shelf in a broad choice of bearings, mountings, ratings, speeds and electrical characteristics.

These up-to-date design features, coupled with careful quality control at each manufacturing step, give you a modern motor you can rely on for all your powering needs. Also, if your needs indicate a custom designed motor Robbins & Myers welcomes the opportunity to discuss your quantity requirements.

Learn all about the many advantages R&M motors offer you by writing today for Bulletin 450-BZ.

**DuPont registered trademark*



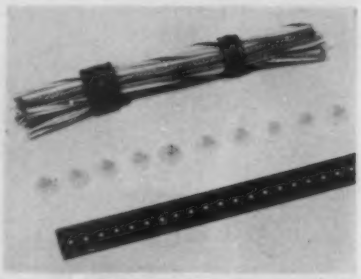
ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

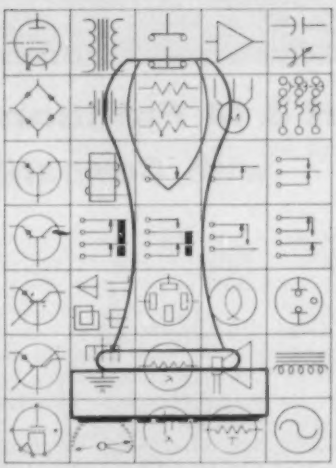
used as relays in circuitry to which it is applied. The two relay contacts can be adjusted to provide additional timed differential at end of time interval. **Eagle Signal Co, Div Gamewell Co, 202-20 St, Moline, Ill.**

Circle 323 on Reader Service Card

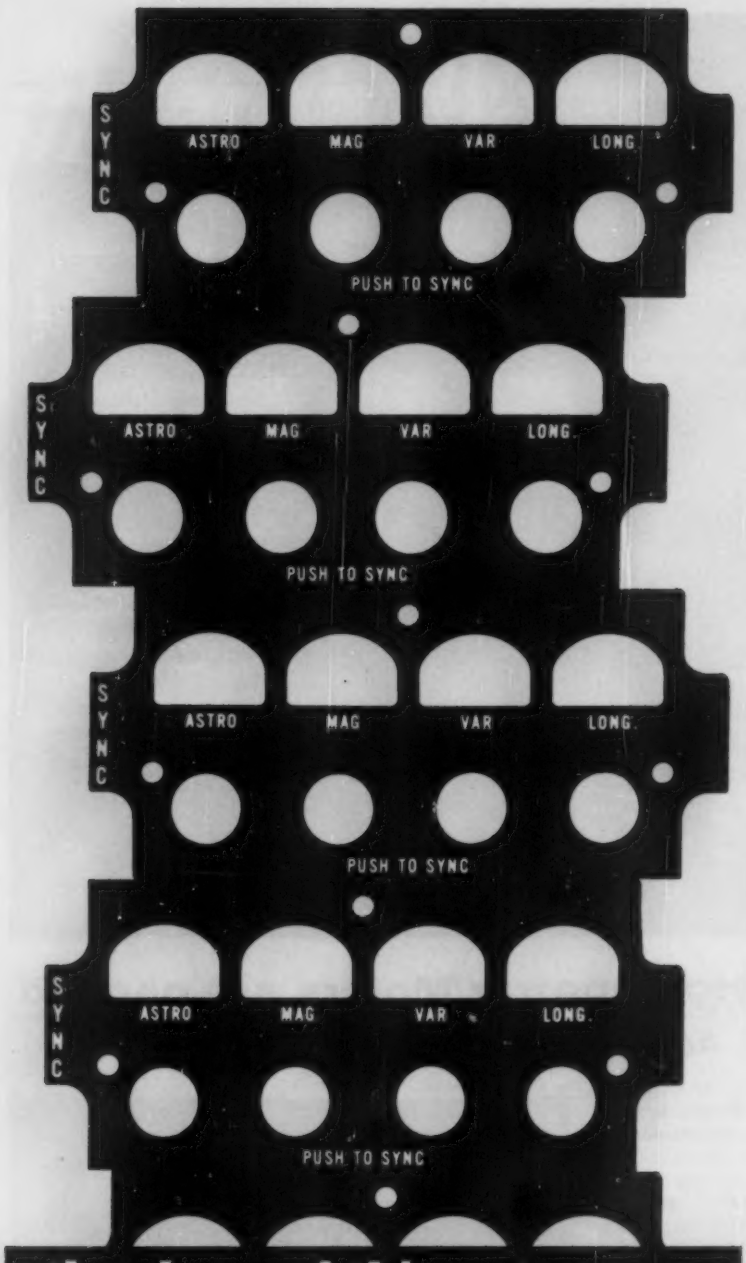


Wire and cable strapping . . . consists of PVC belting with closed-spaced mounting holes and a studlike insert that resembles a collar button in both appearance and function. Strapping is available in 75-ft coils: $\frac{5}{16}$ in. width costs $2.25 per coil, $\frac{1}{2}$ in. width, $3.75 per coil. Studs, $5 per 100. All FOB NY. **Electrovert Inc, 124 E 40th St, NYC.**

Circle 324 on Reader Service Card

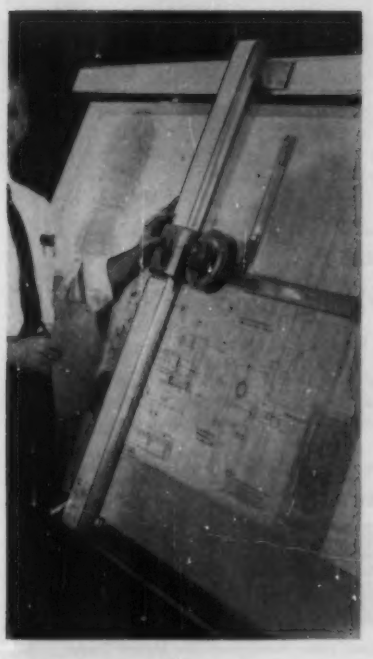


Technical rubber stamps . . . available in either complete sets or as individual stamps, are said suitable for rough sketching, layout and design work and in finished engineering drawings, to be reproduced by blueprinting or other types of equipment. Symbols for welding, electrical and electronic, construction, piping, heat and power and other fields are available. All circular symbols are approximately $\frac{3}{4}$ in. dia; rectangular symbols, $\frac{3}{4}$ in. Special stamp designs can also be produced to order. Fit any standard rubber


SYNC
ASTRO
MAG
VAR
LONG.
PUSH TO SYNC
SYNC
ASTRO
MAG
VAR
LONG.
PUSH TO SYNC
SYNC
ASTRO
MAG
VAR
LONG.
PUSH TO SYNC
SYNC
ASTRO
MAG
VAR
LONG.
PUSH TO SYNC
the shape of things to come
. . . embedded-circuit instrument panels from United States Radium Corporation—one of four new designs incorporating potted circuits for reliability in a variety of industrial and military applications. / These new Lackon panels feature solder-connected wire circuits with "built-in" protection against physical and environmental effects. All wiring is fitted into specially-grooved slots which are then filled, and the panel back finished to provide a smooth, virtually trouble-free surface. / Investigate these longer-lived panels for your critical design needs.
RADIUM
Write for additional details.
united states radium corporation
MORRISTOWN, N. J.
Offices: Chicago, Illinois and North Hollywood, Calif. Subsidiaries: Radelin Ltd., Port Credit, Ont., Canada and U. S. Radium Corp. (Europe), Geneva, Switzerland

stamp rack. Technical Stamp Div, Paper Equipment Distributing Co, P O Box 90, Prince St Station, New York 12.

Circle 325 on Reader Service Card



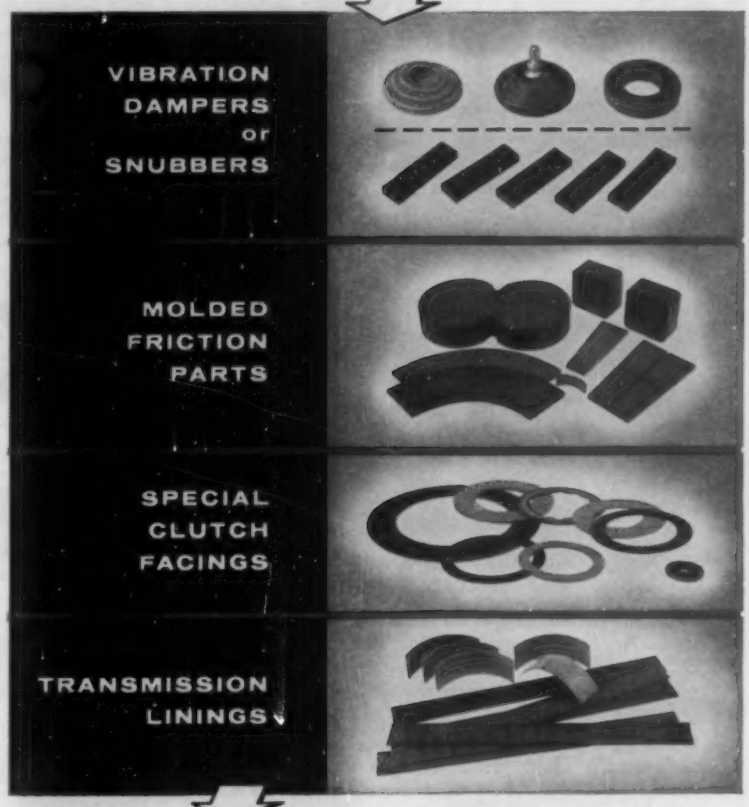
Drafting machine . . .
can be used at any board angle and has ballbearing-equipped horizontal and vertical rail beams that eliminate usual swinging weight arm. Can be locked at a point in one elevation and will then carry that point vertically or horizontally to another view. Guide rails are in center of beams, enclosed by endless nylon tape for protection against dust and erasures. Protractor height-adjustment mechanism permits only scales to touch drawing, and can be swung out of the way to clear objects and insert drawings. Ten-in. numbered grid graduations engine-divided along both X and Y beams are optional equipment. Available for all standard-size boards. Universal Drafting Machine Corp, 7960 Lorain Ave, Cleveland 2.

Circle 326 on Reader Service Card

let **WORLD BESTOS**

help you

in the design and production of



● World Bestos offers you more than 30 years' engineering and manufacturing experience in the producion of molded friction parts. Chances are our immense resources and facilities can supply you with molded parts and friction components—to meet your requirements—at a savings in both time and money.

● Send your blueprints (or samples) for prices and delivery information to WORLD BESTOS, Industrial Products Section, New Castle, Ind., Phone: JAckson 9-4790. Write for free illustrated folder.

WORLD BESTOS NEW CASTLE, INDIANA
DIVISION OF THE
Firestone
TIRE & RUBBER COMPANY

Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

FABROID Self-Lubricating BEARINGS

REDUCE . . .
costs, wear, maintenance, and friction

PROVIDE . . .
reliability, weight-saving, nearly-equal starting and running coefficients of friction

ELIMINATE . . .
lubrication, fretting, brinelling, use of seals

MAGNIFIED PHOTOGRAPHS OF FABROID

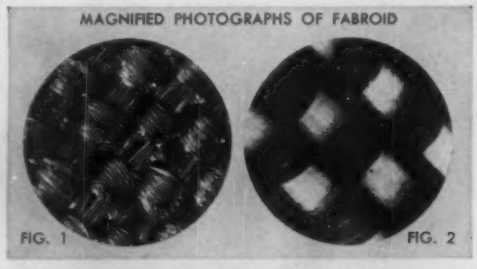


FIG. 1 FIG. 2

10X-STRENGTH PROVIDES MAXIMUM LIFE FOR LOW-SPEED, HIGH-LOAD APPLICATIONS

FABROID consists of two fused layers. The bearing layer (Fig. 1) is a weave of Teflon* fibers interwoven on the back with a layer of phenolic-impregnated glass fibers of high tensile strength (light strands in Fig. 2).

Bonding the two layers under pressure and elevated temperature results in a dense lattice of self-lubricating Teflon fibers which have ten times the strength of other Teflon forms.

**E. I. Dupont's Tetrafluorethylene*

FABROID solves these bearing problems . . .

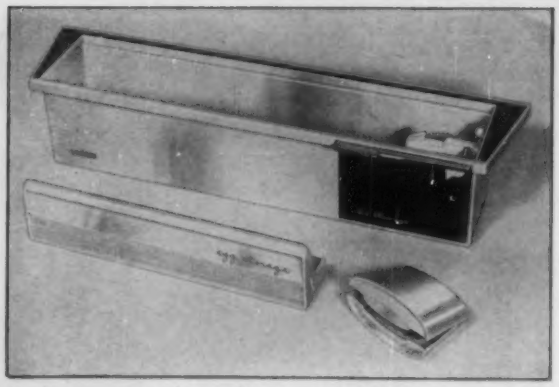
- Lubrication and maintenance
- Extreme temperatures
- Tight space, weight conditions
- Abrading, galling, or corrosion
- Contamination
- Static Friction
- Shock and vibration

There Is No Substitute For Fabroid Bearings

U.S. Pat. No's. 2,804,886; 2,835,521; 2,885,248

MICRO-PRECISION DIVISION

Micromatic Hone Corporation
1535 Grande Vista Ave.
Los Angeles 23, California
PHONE: ANgeles 8-1345



3 fine examples of . . .

Quality Plastic Moldings by SINKO

Pictured above are Ice Cube and Egg Storage units we molded for Admiral Freezers and a Jewel Box . . . all of Styrene, hot-stamped and beautifully multi-colored and finished.

We have been producing fine Plastic Moldings such as these for many years, and are exceptionally well qualified to serve your needs in molded parts.

And we feel certain we can save you money in the process!

WE MOLD ALL THERMOPLASTICS . . . from 2 to 175 oz.

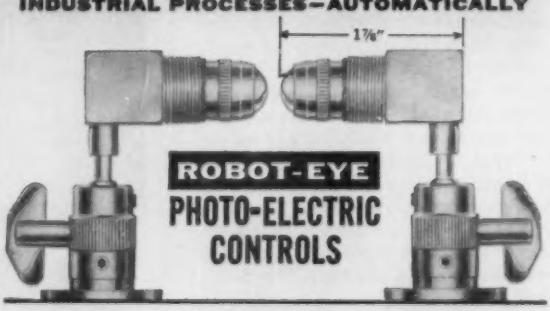
Sinko MANUFACTURING and TOOL CO.
7310 W. WILSON AVE. • CHICAGO 31, ILL.

Offices in principal cities throughout the United States

CIRCLE 204 ON READER SERVICE CARD

count, inspect, control

INDUSTRIAL PROCESSES—AUTOMATICALLY



Transistorized and Tube **AMPLIFIERS**

Plug-in relays, receptacles for plug-in connection of lamps and coils. Additional Plug-in accessories include counters and time delays.

MINIATURIZED
Small, for "tight-spot" installation, yet rugged for long service. Accurate, for precise automatic control in virtually any industry.

INTER-CONNECTING
Plug-in terminals available for quick connection to any of a wide range of Amplifiers. This design enables you to select the most economical amplifier for your job requirements.

INEXPENSIVE
Standard Set P-5 is $17. Set P-5S is $21. Amplifiers start at $39.50. For complete data, write for Brochure YP-8.

standard INSTRUMENT CORPORATION
657 BROADWAY, NEW YORK 12, N.Y.
In Canada: STANDARD INSTRUMENTS (CANADA) LTD.
767 Warden Ave., Scarborough • Toronto, Ontario

DESIGN LITERATURE

The Dynamic Behavior of Thermoelectric Devices

PAUL E GRAY, John Wiley & Sons Inc, 440 Park Ave South, New York 16. 6 x 9, 136 pp. $3.50.

This book is the first published report on small-signal dynamic behavior of thermoelectric devices. Exact analysis of thermoelectric heat pumps and generators is difficult, because these devices are described by differential equations that contain product-type nonlinearities. This approach analyzes linear models, and small-signal transfer functions can be used either to compute the response of devices in the frequency domain, or to calculate the response of devices in the time domain.

Introduction to Modern Network Synthesis

M E VAN VALKENBURG, John Wiley & Sons Inc, 440 Park Ave South, New York 16. 6 x 9, 498 pp. $11.75.

This book begins with a study of Brune's positive real functions, followed by an enumeration of synthesis procedures for LC, RC, RL and RLC one-terminal-pair networks. Other chapters cover: relationship of parts of network functions; two-terminal-pair networks, including Cauer ladder development, the Guillemin and Darlington methods, and image-parameter method.

Structural Mechanics

GOODIER and HOFF, Pergamon Press Inc, 122 E 55th St, New York 22. 6 x 10, 594 pp. $8.

This book contains the papers read by a number of outstanding scientists, together with the discussions that followed them, at the First Symposium on Naval Structural Mechanics, sponsored by the Office of Naval Research of the United States Navy and Stanford University.

Critical reviews and analyses of problems are offered, many of which are of particular significance to the Navy. Included are the results of important recent researches, with an interpretation of their significance for future design applications. The book also discusses the authors' conclusions and opinions regarding the most fruitful directions towards which research programs should be oriented.

Some of the more general topics covered are: trends in materials; developments in the linear theory of elasticity; problems in shell theory; instability in thin elastic shells; vibrations in isotropic elastic plates; wave propagation in solids; dynamic interaction between structures and fluid; aero-hydroelasticity; structure-born noise; and thermal stresses.

The New Product

DELMAR W KARGER. Industrial Press, 93 Worth St, New York 13. 6¼ x 9¼, 234 pp. $5.

Here is a quick look at most of the factors of successful product development. The book describes how to find ideas, how to test, develop, and sell new products. It offers checklists that save a manager from the common pitfalls and help ensure the success of his project. Included are chapters on patents, costing and pricing, market research, advertising. Basic concepts of top-management planning and organization are covered as well as tips on how to sell your ideas to management.

Other Books of Interest

Scientific Explanation

R B Braithwaite. Harper & Bros Inc, 49 E 33rd St, New York. 5½ x 8, 374 pp, $1.85.

A new paperback edition of the original 1953 book; subtitle: "A Study of the Function of Theory, Probability and Law in Science."

The Logic of Modern Physics

P W Bridgman. Macmillan Co, 60 Fifth Ave, New York. 5¼ x 8¼, 228 pp, $1.25.

A paperback edition of a book published originally in 1927. Discusses whether fire, energy and causation are the same when we pass from ordinary mechanics to the physics of the atom and radiation.

United Nations Statistical Yearbook

Columbia University Press, 2960 Broadway, New York 27. 9 x 11½, 618 pp, includes indices, $10 cloth-bound, $8 paper-bound.

This is the UN's annual report on the world's agricultural, industrial and other types of production.

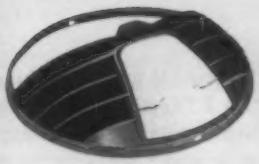
Symposium on Hydraulic Fluids

American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6 x 9¼, 102 pp, $3.75.

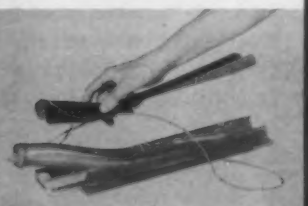
Contains papers presented on Oct 13, 1959, at Third Pacific Area National Meeting of the ASTM in San Francisco.

continued on page 67

RELIABILITY!
VERSATILITY!



. . . APPLIED DIRECTLY TO THE PART

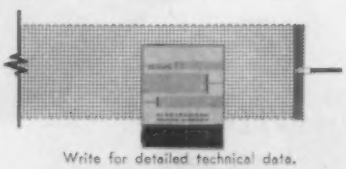


. . . OR TO DETACHABLE COMPONENTS

. . . OR FORMED AS THE PART ITSELF

ELECTROMESH HEATING ELEMENTS

The ultimate in reliability is obtained with this new wire mesh heating element . . . Its current is carried by 36 parallel wires (per inch width of conductor) . . . also 30 wires are interwoven perpendicular to the flow of current. In the event of broken wires or partial open circuits, these cross wires act as buss bars . . . redistributing the current, restoring the element to full power.



Write for detailed technical data.

Electrofilm INC.

P.O. BOX 106, NORTH HOLLYWOOD, CALIFORNIA

NEW J&J VERTILOK

SIDE BRAKE

for Medium Duty Plate Casters

To provide greater locking strength, the J & J "Vertilok" side brake features a vertical cam action and a specially formed brake shoe which contacts the maximum tire tread area. A slight press of the toe and the wheel is securely locked . . . or completely released. Provision is made for adjustment of the braking action to compensate for wheel or tire wear. Simplicity of design and rugged construction assure long, trouble-free life.

Suitable for all 4" to 6" rubber wheels, with hard or soft tread; steel disc replaceable tread wheels, 4", 5" and 6" diameter; also medium casters with standard 4" x 4" top plate.

Sold Through Quality Dealers

Jarvis AND Jarvis, Inc.
PALMER, MASSACHUSETTS

IN CANADA: Jarvis & Jarvis of Canada, 1744 William St., Montreal, Que.

Sales Representatives In Leading Cities Throughout the Country

CIRCLE 206 ON READER SERVICE CARD

SIMPLIFY DESIGN PROBLEMS

Uneven loads will not sway, tip or tilt because off-center load is evenly distributed on both springs. Variable ratio springing adjusts self to road conditions. Deflection rate changes automatically to produce exactly right capacity to properly balance spring tension with load. Lower center of gravity without sacrifice of clearance. Only four bolts to mount . . . no assembly required. Just two friction bearings with renewable friction inserts control spring action.

Prior
LEVEL-LOAD
TRAILER AXLE

PRIOR PRODUCTS, INC. / P. O. BOX 7608 • DALLAS, TEXAS

Vote THE STRAIGHT ECONOMY Ticket!
JOIN THE CAMPAIGN FOR INCREASED PROFIT!
OUR CANDIDATE
Are your "encumbent" bearings spending more of your profits than necessary? Many so-called "anti-friction" bearings cost more than needed to do the job. Today is election day. Switch now to the TRIANGLE PARTY'S reliable, economical self-aligning sleeve-type pillow blocks . . . re-elected term-after-term by leading manufacturers.
— THE TRIANGLE PLATFORM —
QUALITY IMPROVEMENTS
COST REDUCTIONS
SERVICE RELIABILITY
TRIANGLE MANUFACTURING CO.
730 Division St., Oshkosh, Wis.
Write For free campaign literature on the most complete line of self-aligning sleeve bearings and mountings.

66 CIRCLE 66 ON READER SERVICE CARD

CIRCLE 207 ON READER SERVICE CARD

Basics of Induction Heating (2 volumes)

C A Tudbury. John F Rider Publisher Inc, 116 W 14th St, New York City. 6 x 9, Vol 1, 140 pp; Vol 2, 144 pp; $3.90 each (soft cover); $7.80 set (soft cover), $8.90 (cloth binding).

ABSTRACTS FROM THE LITERATURE

Fatigue Under Random Loading

Fatigue life under randomly varying stress amplitudes is discussed in terms of the interaction between infrequent high-stress amplitudes and dominant low-stress amplitudes. An interaction factor is developed that demonstrates validity of a pseudolinear rule of cumulative damage for structural aluminum. Statistical aspects of fatigue under random loading are also discussed.

"Fatigue of Structural Metals Under Random Loading," A. M. Freudenthal, Columbia University. ASTM Preprint 67b. American Society for Testing Materials, 1916 Race St, Philadelphia 3.

Retaining Rings

Discusses various aspects of the application of retaining rings to product designs, such as: basic types of rings, selection, calculation of load capacities (a page of formulas is included), assembly techniques and equipment.

"Technique of Designing with Retaining Rings," Oswald Kolbert, Truarc Retaining Rings Div, Waldes Kohinoor Inc. Design Engineering, June '60, 481 University Ave, Toronto 2, Canada.

Designing for and Determining Product Quality

Discusses product testing, continuous auditing of design quality in parts and assemblies, optimum product service life. Contains curves and some tabular data.

"Engineering Audit of Design Quality," G. W. Schroeder, General Electric Co. Presented at AIEE Subcommittee on Domestic Appliances 11th Annual Technical Conference, Mansfield, Ohio, May 16-17, 1960. American Society of Electrical Engineers, 33 W 39th St, New York 18.

How Rolling-contact Fatigue Life Relates to Mechanical Properties

AISI M-1, AISI M-50, Halmo and WB-49 tool-steel tempered to various hardness levels were tested in bench-type testing apparatus to determine room-temperature fatigue life. Fatigue life increased with hardness; however, elastic-limit and yield-strength measurements made on bar specimens from the same heat of materials showed optimum values at intermediate hardness level. On the other hand, resistance to plastic deformation, measured with ball specimens in rolling contact, did correlate with fatigue life.

"Relation Between Rolling-contact Fatigue Life and Mechanical Properties for Several Aircraft Bearing Steels," Zaretsky and Anderson, Lewis Research Center NASA. ASTM Preprint 63. American Society for Testing Materials, 1916 Race St, Philadelphia 3.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 71.

DC CONTACTORS AND RELAYS – Bulletin GEA-6621A, 32 pp. Includes illustrations, layout and schematic diagrams, application data, specifications for general-purpose, mill-type and time-delay contactors; general-purpose, timing, instantaneous overload and thermal overload, field loss, field accelerating and decelerating, and high drop-out relays. General Electric Co, Schenectady 5, NY.

Circle 350 on Reader Service Card

SCREW-THREAD TECHNOLOGY – Booklet, 16 pp. Outlines history of screw threads; defines present-day terms; explains, with diagrams, major kinds in use today. Charts give measurements and characteristics of standard types, according to Unified and American Thread Series, ASA B 1.1-1060. Data on tapping and wood screws are also included and a torque guide discusses safe loads for bolts of various metals. H M Harper Co, 8200 Le-High Ave, Morton Grove, Ill.

Circle 351 on Reader Service Card

ROTARY GEARPUMPS – Booklet, 36 pp. Discusses operating principle and illustrates application to hydraulic and fluid-handling systems with sample problems. Contains curves on friction loss in pipes, as well as data on viscosity and temperature-conversion charts. Roper Hydraulics Inc, P O Box 269 Commerce, Ga.

Circle 352 on Reader Service Card

HYDROGEN EMBRITTLEMENT IN FASTENINGS–Report No 320, 7 pp. Recommendations for the elimination of hydrogen embrittlement in threaded fastenings are presented and a specification guide is included for the use of designers. Data is also included on electroplating procedures for fasteners for 180,000 to 260,000-psi service. Box 545, Standard Pressed Steel Co, Jenkintown, Penna.

Circle 353 on Reader Service Card

MAGNETIC DRIVES–Bulletin TP 2-60, 11 pp. Describes operation, design, applications, selection procedure and gives dimensions and ratings of various models. Also contains curves on torque vs slip speed. Tormag Products, Div Gleason Reel Corp, 740 Plankinton Ave, Milwaukee 3.

Circle 354 on Reader Service Card

TERMINAL BLOCKS AND SWITCHES–Catalog 16, 33 pp. Contains mechanical and electrical information, ratings, dimensions of blocks, switches, insulating strips, hardware and other accessories. Kulka Electric Corp, 633-643 S Fulton Ave, Mt Vernon, NY.

Circle 355 on Reader Service Card

STEEL TUBING–Technical bulletin 12-10, 4 pp. Selection chart gives types of tubing available, finish, analysis, applications, sizes and wall thicknesses, formability ratings, heat-treatment recommendations, relative costs. Brief discussion included on tubing vs bar stock. Joseph T Ryerson & Son Inc, Box 8000-A, Chicago 80.

Circle 356 on Reader Service Card

POLYPROPYLENE – Booklet, 6 pp. Molding and extrusion characteristics are discussed together with physical, mechanical, electrical and other properties. Eastman Chemical Products Inc, Sub Eastman Kodak Co, 260 Madison Ave, New York 16.

Circle 357 on Reader Service Card

CYLINDERS FOR FLUID POWER – Bulletins A-100, 12 pp, and H-100, 8 pp. Contain, respectively, information on 1½ to 14-in. bore air cylinders for 200-psi air, 500-psi oil service and 1½ to 12-in. bore hydraulic cylinders for 2000 to 3000-psi

continued on page 69

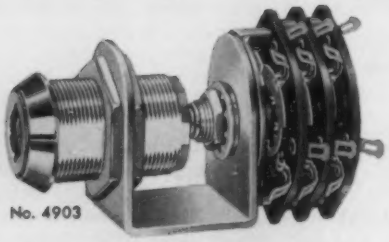
". . . well then do your 'creating' on your own time!"

NEW

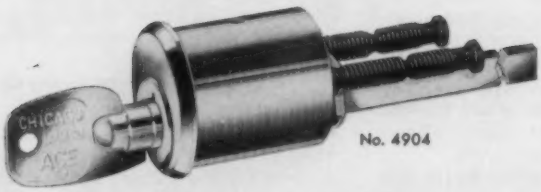
UNDERWRITERS' LISTED

CHICAGO ACE®

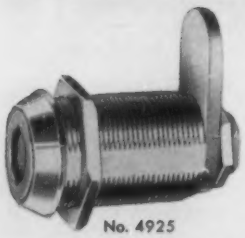
PIN TUMBLER LOCKS



No. 4903

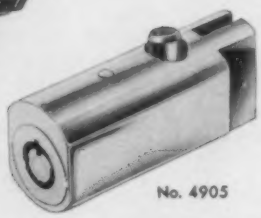


No. 4904



No. 4925

Hardened Steel ACE Key



No. 4905

Here is the only line of locks listed by Underwriters' Laboratories. The unique ACE Locks provide the maximum in mechanical security. Over 80,000 keying combinations are possible so that you may have your own factory-registered tumbler set-up. For technical details on models available for various applications, write for Switch Lock Bulletin UB 501.

CHICAGO LOCK CO.

2050 N. Racine Avenue • Chicago 14, Illinois

Wilbow **GIVES YOU VERSATILITY AND PRECISION IN RUBBER COVERED ROLLS**

28 WILBOW
Rubber Covered Rolls protect the large glass panels going through new "SOMACA" Automatic Glass Washing and Drying Machines.

In preparing plate glass for mirror silvering, rubber covered rolls must meet a wide range of vital requirements—precision for accurate support and guidance, uniformity for steady feeding pressure, controlled resiliency for squeegee drying. That's why Sommer and Maca specify rolls by WILBOW.

With years of specialized experience, WILBOW offers rubber covered rolls in the broadest range of sizes, in natural or synthetic rubbers, with the widest choice of finishes and physical properties. Let WILBOW help you select the ideal rolls for your application – and then rely on WILBOW to supply them.

Wilbow

The WILLIAMS-BOWMAN RUBBER Co.

1955 South 54th Avenue • Cicero 50, Illinois • (Chicago Suburb)

Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

CIRCLE 208 ON READER SERVICE CARD

In Checking Surface Roughness

In judging microinch roughness by eye or by "feel," sometimes you'll get the right answer, and sometimes not. *You can never be SURE;* for the "confusion factors" are many, and the brain misinterprets what the senses report — the same as with optical illusions.

That's one reason why industry depends on a confusion-proof *shop instrument*—the PROFILOMETER®—when dependable roughness measurements are required.

FREE BULLETIN LT1 shows why surfaces that look alike, or feel alike, often differ in roughness by several hundred percent. *Write for it!* You'll be interested, and perhaps surprised.

Profilometer is a registered trade-mark.

MMC **MICROMETRICAL MANUFACTURING COMPANY**

3621 S. State Rd. Ann Arbor 5, Michigan

CIRCLE 68 ON READER SERVICE CARD

CIRCLE 209 ON READER SERVICE CARD

service. Milwaukee Cylinder Co, Div L&M Machine Co, 5757 S Pennsylvania Ave, Cudahy 7, Wis.

Circle 358 on Reader Service Card

COUPLINGS FOR TUBING—Bulletin 801, 4 pp. Contains design information on couplings for use with tubing, piping, ducts, containers or structural devices for both aircraft and industrial applications. Aeroquip Corp, Marman Div, 11214 Exposition Blvd, Los Angeles.

Circle 359 on Reader Service Card

THERMISTORS – Manual EMC-3, 24 pp. Describes thermistors and gives examples of how they are applied. Also contains listing of available types and their ratings, together with a resistance-temperature table and slide rule. Fenwal Electronics Inc, 51 Mellen St, Framingham, Mass.

Circle 360 on Reader Service Card

CAST ACRYLIC RODS AND TUBES—Brochure, 8 pp. Describes applications; lists mechanical, thermal, electrical, optical properties. Also provides details on available types. Cadillac Plastics & Chemical Co, 15111 Second Blvd, Detroit 3.

Circle 361 on Reader Service Card

LIQUID-LEVEL WINDOWS – Bulletin 8-E, 4 pp. Windows intended for viewing reservoir or crankcase oil level, constant-flow checkpoint, and as a protective cover for meter face are described and available sizes and types listed. Bijur Lubricating Corp, Rochelle Park, NJ.

Circle 362 on Reader Service Card

AC POTENTIOMETERS AND ADJUSTABLE - FUNCTION GENERATORS—Catalog, 12 pp. Describes design features, applications and operation of ac potentiometers and adjustable-function generators. Also presents design objectives and specifications of each unit. Perkin-Elmer Corp, Norwalk, Conn.

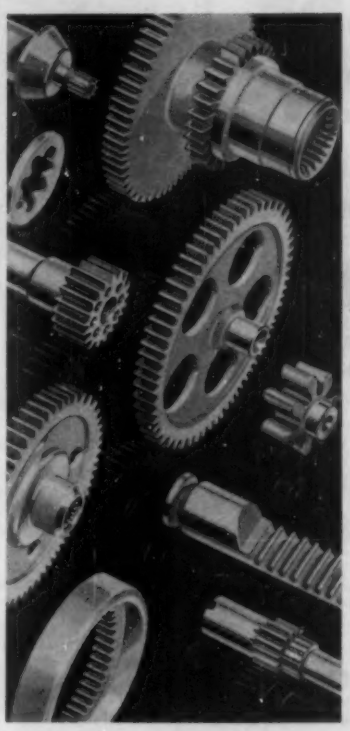
Circle 363 on Reader Service Card

ADJUSTABLE ELECTRICAL SPEED DRIVES—Bulletins SL-351-460 and SL-532-560, 8 pp each. Contain specifications, design and construction details, operational, installation and application information on drives for up to ½ and up to 3.4 hp maximum. Cleveland Machine Controls, Inc, 1155 Brookpark Road, Cleveland 9.

Circle 364 on Reader Service Card

ENVIRONMENTAL TESTING – Brochure 600, 32 pp. Color chart summarizes known data on specific weight, pressure, acceleration of gravity, molecular weight at altitudes from sea level to 2 million ft. Other charts give data on atmosphere,

continued on page 71



ACCURACY at EQUITABLE is measured in SECONDS

Many products contributing to missile age advancement are precision-geared to super-critical tolerances by Equitable Engineering. No problem is too great . . . or too small . . . for Equitable's complete gear design and production plant. So if you want a major gain in gear accuracy—call or write now.

. . . all about EQUITABLE

This fact-filled 16-page catalog describing Equitable's abilities is yours for the asking.

EQUITABLE

ENGINEERING COMPANY

2724 Normandy Rd., Royal Oak, Mich. • LIberty 9-5300

Member: American Gear Manufacturers' Association

CIRCLE 210 ON READER SERVICE CARD

"YOU'RE RIGHT, BRUTUS . . . POLO PLASTICS DOES HAVE THE ANSWER." In the design and fabrication of flexible vinyl plastics — such as products, parts, components and packaging — Polo Plastics is yet to be baffled. Polo designers and production engineers do things with flexible film vinyl that meet the highest standards. They can stitch . . . zip . . . sew . . . hem . . . weld . . . snap . . . print . . . in any size or shape, in an array of colors, gauges and textures. Whether your problem is unique or simple, depend on the versatility and practical know-how, of Polo Plastics.

SEND US YOUR PROBLEM OR SPECIFICATIONS FOR ANALYSIS, ESTIMATE AND SAMPLE SWATCH BOOK.

POLO plastics co.

1718 N. 1st St. / Milwaukee, 12 Wis. Dept. B

CIRCLE 211 ON READER SERVICE CARD

Strataflo

CHECK VALVES

for semi-solid and liquid food handling equipment

New valve resists acids, will not contaminate

The new No. 3300 Strataflo Check Valve is designed to eliminate many of the problems encountered in semi-solid and liquid food handling equipment. Acids cannot harm the rugged one-piece body which is cast of a high nickel alloy. A large port area and unique straight line flow give greater capacity with low restriction. There are no "pockets" to fill up and encourage contamination. Easily cleaned by back-flushing. Leak-proof Neoprene poppet is non-toxic, odorless and tasteless. Valve will operate in any position; 200 lbs. working pressure. Available in three sizes: ¾", 1" and 1¼". Write for Bulletin 204 for information and prices.

STRATAFLO PRODUCTS, INC.

FORT WAYNE, INDIANA

CIRCLE 69 ON READER SERVICE CARD

there are **MOORE SET SCREWS**

exactly right for any job . . . and you can get them FAST

Dependable delivery — ample production capacity assures that you get any order, large or small, on schedule.

Uniform high quality — modern equipment and methods and rigid quality control guarantee precision quality.

Advice of specialists — expert engineering assistance, backed by 80 years of experience, is available to help solve problems.

Moore set screws simplify design, purchasing, production. Send for price catalog.

MOORE SET SCREWS

George W. Moore, Inc.
since 1880
92 Beaver St., Waltham 54, Mass.

CIRCLE 212 ON READER SERVICE CARD

MOLDING

for the Furniture Industry

Not only does Patent offer custom plastic molded legs for sofas, chairs, tables, hassocks, television sets, etc., but service to many other industries as well. Complete facilities for compression, injection and plunger type molding provide unlimited product design. Send your inquiry today!

PLASTIC MOLDING DIVISION OF

Patent BUTTON CO. of TENN. Inc.

KNOXVILLE, TENNESSEE PHONE 2-9621

CIRCLE 213 ON READER SERVICE CARD

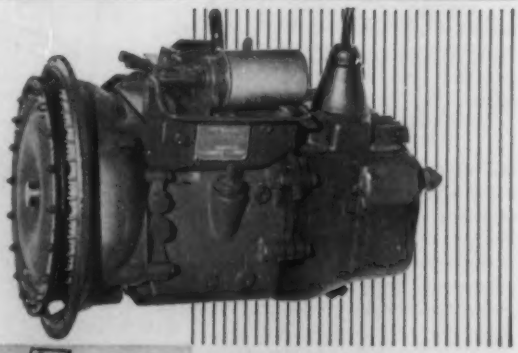
ALLENAIR CORP., 255 East 2nd St., Mineola, N. Y. PEG-8

Name.....

Company.....

Address.....

City.....Zone.....State.....



FUNK UNITS ASSURE SMOOTH POWER SHIFTING

On this Getman Scoot-Crete ore carrier, a FUNK Revers-O-Matic® Drive installation delivers smooth, instant power shifting — forward and reverse — with just one foot pedal. And a FUNK TORQUE CONVERTER automatically adjusts power to speed and load requirements, eliminates wheel spinning.

Just one example of how FUNK MODULAR POWER UNITS may be combined — in an unlimited number of arrangements — *without* special engineering costs.

Let FUNK help solve your power transmission problem.

FUNK MFG. CO. Box 577-D, Coffeyville, Kansas

CIRCLE 214 ON READER SERVICE CARD

CIRCLE 70 ON READER SERVICE CARD

temperature and humidity. Various types of environmental chamber and other equipment are described, and their dimensions, ratings, and design detailed. Webber Mfg Co, P O Box 217, Indianapolis.
Circle 365 on Reader Service Card

HOSE CLAMPS—Catalog 1-103, 4 pp. Minimum and maximum clamp diameters, hose diameters, band and screw lengths are listed. Construction is described and recommendations for use included. Ideal Corp, 435 Liberty Ave, Brooklyn 7, NY.
Circle 366 on Reader Service Card

TUBING AND BAR WEIGHT COMPARISON—Bulletin, 4 pp. Contains tables comparing weight of welded steel tubing and bar stock. Also includes data on driveshaft-torque values, properties and available sizes of tubing. Standard Tube Co, 24400 Plymouth Road, Detroit 39.
Circle 367 on Reader Service Card

CAPACITORS AND RELAYS—Folder, 4 pp. Provides construction details, voltage, capacity, performance of high voltage, wet slug and tantalytic capacitors and microminiature relays made by General Electric. Schweber Electronics, 60 Hericks Road, Mineola, NY.
Circle 368 on Reader Service Card

RADIATION—Booklets (2), 4 pp each, discuss nature of radiation or radio-activity in a two-part article. R S Landauer Jr & Co, 3920 216 St, Matteson, Ill.
Circle 369 on Reader Service Card

CENTRIFUGAL PUMP—Bulletin M60, 4 pp. Describes operation of pump with canned stator and flow-through-type rotor-impeller. Gives specifications, dimensions and includes curves showing capacities. Corley Co, Inc, 685 Myrtle Ave, Boonton, NJ.
Circle 370 on Reader Service Card

BRAKE-SAFETY SYSTEM—Brochure, 4 pp. Describes three-way safety-braking system originally developed for school buses. Kelsey-Hayes Co, 3600 Military Ave, Detroit 32.
Circle 371 on Reader Service Card

VIBRATION ISOLATOR—Bulletin 59-04-10. 2 pp. Describes construction, shows mounting methods, and gives ratings. Barry Controls Inc, 700 Pleasant St, Watertown 72, Mass.
Circle 372 on Reader Service Card

STANDARD RESINS—Wall chart. Revised chart tabulates property data, features and application information about epoxy and ceramic-type casting and impregnating resins and adhesives. Emerson & Cuming Inc, Canton, Mass.
Circle 373 on Reader Service Card

GAS COMBUSTION AND CONTROL—Catalog(88 pp. Describes burners, mixers, pilots, regulators, blowers, valves, and accessories. Gives data on sizes, capacities, applications. Bryant Industrial Products Corp, 17700 Miles Ave, Cleveland 28.
Circle 374 on Reader Service Card

PRESSURE-REDUCING AND RELIEF VALVE—Catalog sheet, 2 pp. Includes design details, operation, installation and specification information on valve intended for initial pressure of 400 psi with water, oil, air or gas. Atlas Valve Co, 280 South St, Newark 5, NJ.
Circle 375 on Reader Service Card

CONSTANT-MODULUS TUBING—Data memorandum 19, 2 pp. Tables show chemical analysis, properties. Graph gives heat-treatment curves for optimum thermoelastic coefficient. Superior Tube Co, 1556 Germantown Ave, Norristown, Penna.
Circle 376 on Reader Service Card

MEASUREMENT AND CONTROL PRODUCTS—Catalog sheet T-60, 2 pp. Describes instruments and accessories for indication, recording or control of temperature. Arthur C. Ruge Assoc Inc, Hudson, NH.
Circle 377 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

GEARS AND GEARBOXES—Brochure, 20 pp. Describes facilities for manufacture and gives types, sizes, capacities and other characteristics of gearing that can be produced. Includes design data on gear materials, tables of tooth parts, spur-gear proportions, various types of spline shafting. Hardness conversion for alloy steels is also provided. Cincinnati Gear Co, Wooster Pike and Mariemont Ave, Cincinnati 27.

". . . but won't it put a lot of people out of work?"

REPRINTS

As long as the supply lasts, readers in US and Canada can secure one copy of "P" lettered reprints, without charge, by using one of the Reader Service cards bound inside the back Cover. Note that the card must be used within 60 days of publication date.

Equations for 5 Tapered Cantilever Beams ..... P 56
Digital Storage Devices ..... P 55
Epicyclic Gear Systems ..... P 54
Belt Drives ..... P 53
Selecting the Right Solenoid ..... P 52
Pneumatics Simulate Electronics ..... P 51
Wear Life of Rolling Surfaces ..... P 50
Electrical Analogs Simplify Heat-flow Analysis ..... P 49
Shaping Vulcanized Fibre Parts ..... P 48
Centralized Lubrication ..... P 47
Integral Ballbearings ..... P 46
3-D Harness Wiring ..... P 45
Standards for Metal Hose ..... P 44
Marking Your Part ..... P 43
7 Steps to Better Oral Reporting ..... P 42
Best Results with Printed Wiring ..... P 41
Elliptical Gears ..... P 40
Variable-Speed Motor Drive ..... P 39
Faster Ways to Set Statistical Tolerances ..... P 38
4 Types of Vibrators ..... P 37

SPECIAL REPORTS

Here is a list of special reports still available. You may obtain them by writing Reader Service Dept., PRODUCT ENGINEERING, 330 W 42 St., New York 36. Please enclose remittance with order; we pay postage.

Journal Bearing Design (25¢) ..... R 60
Designing Brazed Joints (25¢) ..... R 59
Avoiding Hose Failure (25¢) ..... R 58
How to Select Miniature Lamps (25¢) ..... R 57
How to Predict Buckling Conditions of Coil Springs (25¢) ..... R 56
Photosensitive Glass and Chemical Machining (25¢) ..... R 55
Solid Aluminum Bearings (25¢) ..... R 54
Significance of WK^2 (25¢) ..... R 53
You and Your Employer (25¢) ..... R 52
How to Choose the Right Solder Flux (25¢) ..... R 51
Magnesium Finishes (25¢) ..... R 50
Positive-Displacement Pumps (25¢) ..... R 49

Materials and Processes for Reinforced-plastic Molded Parts

Here is a 60-page combined reprint of 11 articles presenting design data on the seven processes for producing glass-reinforced plastic parts in commercial volume applications. $2 ..... R 48

Fastening Gears to Shafts ..... R 47
Manual for Reliability (32 p 50¢) ..... R 46
Stress Analysis of Combined Loads on Beams (25¢) ..... R 45
Aluminum Diecastings (25¢) ..... R 44
The Rare Earth Metals (25¢) ..... R 43
Hand-Lay-Up (25¢) ..... R 42

— Employment —

I dreamed... I WENT FISHING IN MY MINNESOTA MUKLUKS

Fish were flopping in—already filleted. One cried, "How muk luk can you expect?" We consider we're "lucky" to live and work in Minnesota, just a few hours' drive from the fabulous "north woods" lake and vacation country. To show we're not remotely situated, it takes even less time for a jet to whisk anyone from Minneapolis to West, East or Gulf coasts.

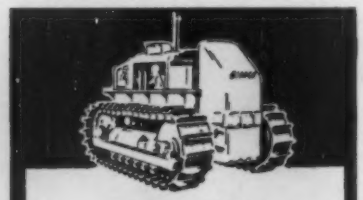
Write about employment opportunities at Flui-Dyne, one of the area's smaller (and thriving) aero-space industries. We're close to the university. Smog is unknown. There is room to grow here . . . for a top man to reach full professional stature. Wives, too, find lots to like in Minnesota.

Immediate openings: (1) EXPERIMENTAL PHYSICIST and (2) ELECTRONICS ENGINEER—for Advanced Planning Division, on problems of measurement and control, advanced equipment. Good report writers. Graduate deg. desir. At least 5 years exp. Salary to $12,000 (3) MECHANICAL DESIGN ENGINEER—for complex test fixtures, facilities. Exper. in design for (-450°F to 5000°F) environments desirable. Considerable proposal work. At least 5 yrs. design exper. Salary to $11,000. (4) ASSISTANT PROJECT ENGINEER—for major facilities, wind tunnels, space simulation equip., etc. Fluid dynamics exper. plus training in at least one additional engineering specialty (electronics, structural, etc.) required. At least 2 yrs. exper. Salary to $9,600.

FLUIDYNE ENGINEERING CORP.

Write
J. Leonard Frame,
Pres.

5740 Wayzata Boulevard,
Minneapolis 16, Minn.



MECHANICAL DESIGN ENGINEERS

Earthmoving experience, with successful record in design and development of heavy mechanical equipment, crawler tractors, bulldozers, winches and tractor attachments.

Work includes layout and design of heavy machinery for construction and mining.

Permanent position open, for those qualified, with one of the nation's fastest growing heavy machinery manufacturers.

Location—Salt Lake City, Utah—in the mountain West, where you can breathe clean air, and drive from home to work in less than 20 minutes.

Send Complete Information and photograph to Dept. SX8

THE EIMCO CORPORATION

P. O. Box 300, Salt Lake City 10, Utah

INDEX OF PRODUCTS
ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD

A

Amplifiers 64
Axles 66

B

Bearings
Ball ..... 4th Cover, 5, 28, 57
Miniature 28
Needle 57
Roller ..... 4th Cover, 57
Self-Lubricating 64
Sleeve 66

C

Casters 66
Control Panels & Switchboards 62, 73
Controls
Electrical 64
Hydraulic 7
Pneumatic 7, 14
Conveyor Belts 8-9
Couplings
Hose 23
Mechanical 70
Tube 23
Cylinders
Hydraulic 7
Pneumatic 7, 14, 70

D

Deep Drawing 24
Drives
Right-Angle 70

E

Engineering Services (see also Production Services) 22
Engines 30
Extrusions
Nonmetallic 68

F

Fabricated Plastics (see Plastics, Fabricated)
Facings, Clutch 63
Fastening Methods 70
Fittings, Hose, Pipe & Tube 23
Friction Materials 63

G

Gaskets 13
Gear Motors (see also Motor Reducers) 74
Gears 69

H

Heating Units 65
Hose & Tubing 23
Hydraulic Fluids 54

I

Instruments
Mechanical 25-26, 68

J

Jacks 59
Joints
Ball 60
Swing & Swivel 60

L

Lamps, Indicator 58
Linings, Brake 63
Locks 68
Lubricants 54
Lubricating Equipment ..... 2nd Cover

M

Metal Forming 24
Moldings
Plastics (see Plastic Parts)
Rubber (see Rubber Parts)
Motors, A-C
Fractional 61, 74
Integral 61, 74
Motors, D-C
Fractional 61, 74
Integral 61, 74

P

Packings 13
Pillow Blocks 66
Plastic Parts 64, 69, 70
Plastics 69
Plastics Fabricated 64
Power Packs
Electrical & Electronic 70
Production Services (see also Engineering Services) 22
Profilometers 68
Pumps
Liquid 52

R

Regulators
Pneumatic 14
Revolving Joints (see Joints, Swing & Swivel)
Rod Ends 5
Rubber Bonded-to-Metal 68
Rubber Parts ..... 3rd Cover, 68

S

Screws 70
Seals ..... 3rd Cover, 13
Spinning 24

T

Tables, Dial-Feed 70
Thermostats 2
Torque Converters (see Couplings)
Transmissions 70
Tube Fabricating 27
Tubes 27
Tubing
Seamless 27

V

Valves
Air 7, 14, 70
Hydraulic 7, 69
Solenoid 14

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

AllenAir Corp. 70
American Cast Iron Pipe Co..... 27
Anchor Coupling Co., Inc..... 23
Armstrong Cork Co..... 13

Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div....25-26
Barco Mfg. Co..... 60

Chicago Lock Co..... 68

Duff-Norton Co. 59

Electrofilm, Inc. 65
Equitable Engineering Co..... 69

Fairbanks, Morse & Co., Pump & Hydraulic Div. 52
Farval Corp., Subs. of Cleveland Worm & Gear Co.....2nd Cover
Funk Mfg. Co..... 70

General Electric Co., Miniature Lamp Dept. 58
Globe Industries, Inc..... 74

Heim Co. 5

Industrial Electronic Engineers, Inc.. 73
International Harvester Co., Engine Sales Dept. 30

Jarvis & Jarvis, Inc..... 66

Kaupp & Sons, C. B..... 24
Kaydon Engineering Corp..... 57

Logansport Machine Co., Inc..... 7

Micromatic Hone Corp., Micro-Precision Div. 64
Micrometrical Mfg. Co..... 68
Minnesota Rubber Co.....3rd Cover
Moore, Inc., George W..... 70

New Departure Div., General Motors Corp. 28

Patent Button Co. of Tennessee, Inc.. 70
Polo Plastics Co. 69
Prior Products, Inc..... 66

Reed Instrument Bearing Co., Div., SKF Industries, Inc.....4th Cover
Robbins & Myers, Inc..... 61

SKF Industries, Inc., Reed Instrument Bearing Co. Div.....4th Cover
Schrader's Son, A., Div., Scoville Mfg. Co., Inc. 14
Shell Oil Co..... 54
Sinko Mfg. & Tool Co..... 64
Standard Instrument Corp..... 64
Stevens Mfg. Co., Inc..... 2
Strataflo Products, Inc..... 69

Triangle Mfg. Co..... 66

U. S. Radium Corp..... 62
U. S. Rubber Co., Mechanical Goods Div. 8-9
U. S. Testing Co., Inc..... 22

Williams-Bowman Rubber Co..... 68
World Bestos Corp., Div., Firestone Tire & Rubber Co..... 63

LLOYD R. LAWRENCE *advertising sales manager*
P. F. PRITCHARD *manager, market development*
THOMAS R COASH *circulation*
RUSSELL T DOUGLAS *business manager*

ADVERTISING SALES STAFF

ATLANTA 3 . . . Ray K. Burnet, 1301 Rhodes-Haverty Bldg, Jackson 3-6951
BOSTON 16 . . . M. A. Williamson, Jr., 350 Park Square Bldg, Hubbard 2-7160
CHICAGO 11 . . . Mid-Western Adv Sales Manager, A. E. Meanor; R. W. Bruley. L. Anderson, 520 N Michigan Ave, Mohawk 4-5800
CLEVELAND 13 . . . A. F. Tischer, 1164 Illuminating Bldg, 55 Public Sq, Superior 1-7000
DALLAS 1 . . . John Grant, 901 Vaughn Bldg, 1712 Commerce St, Riverside 7-5117
DENVER 2 . . . John W. Patten, Tower Bldg, 1700 Broadway, Alpine 5-2981
DETROIT 26 . . . P. B. Robinson, 856 Penobscot Bldg, Woodward 2-1793
HOUSTON 25 . . . Gene Holland, W-724 Prudential Bldg., Jackson 6-1281
LOS ANGELES 17 . . . Robert Obenour, 1125 West 6th St, Huntley 2-5450
NEW YORK 36 . . . B. K. Adams, F. J McKinley, 500 Fifth Ave, Oxford 5-5959
PHILADELPHIA 3 . . . John B. Lewis, K. S. Willadson, 6 Penn Center Plaza, Locust 8-4330
PITTSBURGH 22 . . . C. F. Leveroni, 4 Gateway Center, Express 1-1314
ST LOUIS 8 . . . R. W. Bruley, 3615 Olive St, Continental Bldg, Jefferson 5-4867
SAN FRANCISCO 4 . . . W. C. Woolston, 68 Post St, Douglas 2-4600

SUBSCRIPTIONS. Send subscription correspondence and change of address to Fulfillment Manager, PRODUCT ENGINEERING, 330 W 42nd St, New York 36, NY. Subscribers should notify Fulfillment Manager promptly of any change of address including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Since copies are addressed one to two issues in advance, please allow one month for change of address to become effective. Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. Position and company connection must be indicated on subscription orders.

OFFICERS OF THE PUBLICATIONS DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator. OFFICERS OF THE CORPORATION: Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES ...72-73

Index to Advertisers appears on P. 73
Products Index appears on P. 72

Proven, Dependable, Rear-Projection Type

IN-LINE DIGITAL DISPLAYS

A Model and Size for Your Every Requirement

Series 80000
Series 10000
Series 120000

OUTSTANDING FEATURES

- All digits displayed on front viewing screen
- All digits uniform in size and intensity
- High-contrast viewing screen
- Digit style of your choice
- Colored digits of your choice
- Individual units may be group assembled for panel mounting

WRITE TODAY FOR COMPLETE SPECIFICATIONS
Representatives in principal cities

PRICES

Series 10000
1 1/16" wide
2 5/8" high
5 5/8" long
$18.00 each

Series 80000
3 1/4" wide
5 1/4" high
11 15/16" long
$33.00 each

Series 120000
1" wide
1 1/16" high
3 7/8" long
$35.00 each

Quantity Prices On Request

INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
5528 Vineland Avenue,
North Hollywood, Calif.

Circle 73 on Reader Service Card

EMPLOYMENT OPPORTUNITIES

DISPLAYED RATE

The advertising rate is $37.00 per inch for all advertising appearing on other than contract basis. Frequency rates quoted on request.

UNDISPLAYED RATE

$2.10 per line, minimum 3 lines. Position Wanted ads in this style ½ the above rate. To figure advance payment count 5 average words to a line.

ENGINEER DESIGN

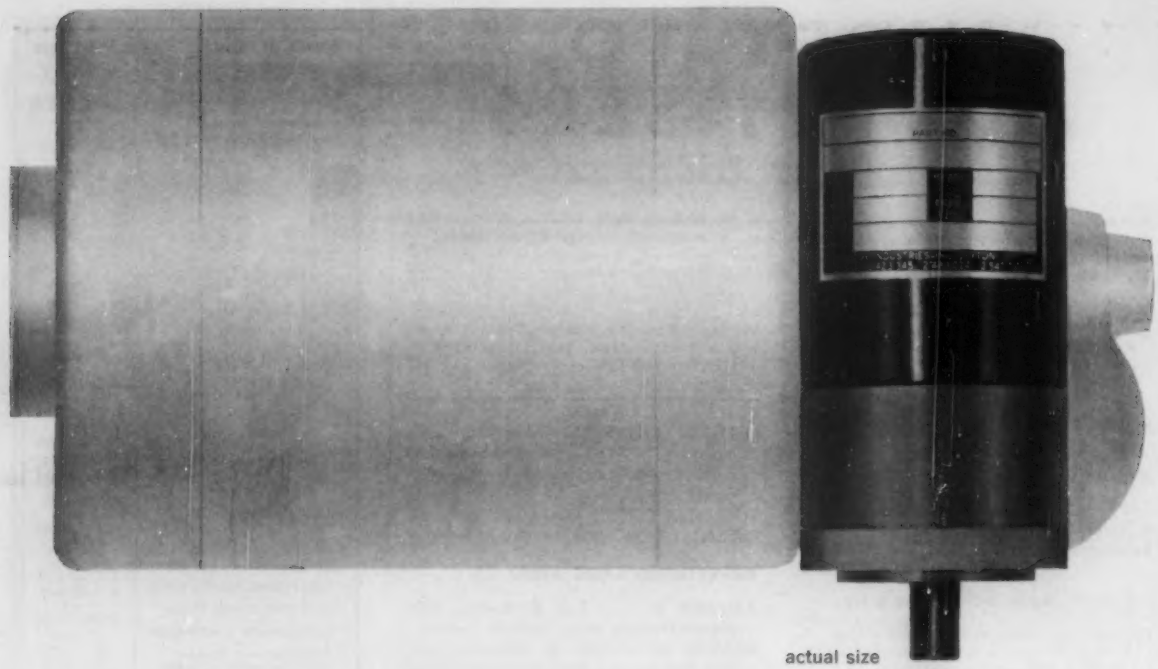
Excellent opportunity for a senior tool design engineer. Experience in design and development of impact extrusion tools or forging tools. ME degree or equivalent. Send complete resume to

KAISER ALUMINUM & CHEMICAL CORP.
Box 566, Erie, Penna.

ADDRESS BOX NO. REPLIES TO: Box No. Classified Adv. Div. of this publication. Send to office nearest you.
NEW YORK 36: P. O. Box 12
CHICAGO 11: 520 N. Michigan Ave.
SAN FRANCISCO 4: 68 Post St.

POSITION VACANT

Electromechanical engineer to assume major responsibility for design and development of special machinery of all types. Should have interest and at least three years' background in mechanical design, electromechanical systems, and automatic control. Duties include concept, feasibility studies, design, experimental development, and prototype acceptance. Varied assignments in the professional atmosphere of a medium-sized industrial research center. Interview and moving expenses paid. Submit resume, or write for application, to Southern Research Institute, 2000 Ninth Avenue South, Birmingham 5, Alabama.



actual size

GEARMOTORS 3/4 SMALLER

The Globe a.c. gearmotor you see superimposed against a conventional right-angle gearmotor will give your product major advantages: Globe's version is much smaller than the big style, is interchangeable with slight mounting changes, produces the same torque, and should run 5 to 7 times as long without maintenance, even with high inertia loads. Study the picture above with **your** application in mind.

Furthermore, Globe gives you a choice of 101 **standard** planetary gear ratios, and any special ratios or other features you need. The Globe gearmotor is competitive in cost even though it meets military specifications. If you don't have rigid environmental requirements Globe can furnish a commercial version in production quantities at a saving to you. If you design with induction or hysteresis synchronous gearmotors—investigate now.

Globe has available for **immediate** shipment prototypes of the Type FC, 115v. a.c., 60 cycle synchronous motor in the following gear ratios: 352.6 to 1 (10.2 rpm, 160 oz. in. out), and 27.94 to 1 (64.4 rpm., 19 oz. in. out). Other variations, including d.c., about 4 week delivery. Please request Bulletin FCB from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, STEPPERS, BLOWERS, FANS, MOTORIZED DEVICES

PERSONAL READER SERVICE

USE ATTACHED CARDS FOR PERSONAL COPIES OF ADDITIONAL PRODUCT DESIGN DATA

. . . Data on Materials and Components
. . . Free Article Reprints
. . . New Catalogs and Bulletins
. . . Brochures on Advertised Products
. . . Personal Suscriptions to PRODUCT ENGINEERING

Valuable new data on product design engineering — readily available to you — FREE.

Just circle the numbers on the request cards that are identical with the numbers printed under each Advertisement, New Product and Bulletin throughout this issue.

Reprint numbers are prefaced with the letter "P". *One free reprint* is available for each article offered.

Issue of August 1, 1960
PRODUCT ENGINEERING
Card expires October 3, 1960

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

USE THIS CARD

to be sure that you get your personal copy of the Design Digest issue mailed in mid-September.

This comes as part of every regular subscription (U.S.A.) at $3.00 per year.

This single popular issue will contain more than 600 pages of basic design information . . . organized and indexed for ready reference.

Issue of August 1, 1960
PRODUCT ENGINEERING

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Depar ment

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

ADD TO YOUR DESIGN REFERENCE FILE FROM

EDITORIAL REPRINTS AVAILABLE

(Single reprint free — quantity prices on page 71)

P37—FOUR TYPES OF VIBRATORS—3/7/60

P38—FASTER WAY TO SET STATISTICAL TOLERANCES—3/21/60

P39—VARIABLE SPEED MOTOR DRIVE—3/28/60

P40—ELLIPTICAL GEARS—3/28/60

P41—BEST RESULTS WITH PRINTED WIRING—4/4/60

P42—7 STEPS TO BETTER ORAL REPORTING

P43—MARKING YOUR PART—4/4/60

P44—STANDARD FOR METAL HOSE—4/11/60

P45—3-D HARNESS WIRING—4/18/60

P46—INTEGRAL BALL BEARINGS—4/25/60

P47—WHEN TO SPECIFY CENTRALIZED LUBRICATION—5/2/60

P48—THESE NINE WAYS FOR SHAPING VULCANIZED FIBRE PARTS—5/2/60

P49—ELECTRICAL ANALOG SIMPLIFIES HEATFLOW ANALYSIS—5/2/60

P50—WEAR LIFE OF ROLLING SURFACES—5/9/60

P51—PNEUMATICS SIMULATES ELECTRONICS—5/9/60

P52—SELECTING THE RIGHT SOLENOID—5/23/60

P53—BELT DRIVES—5/30/60

P54—EPICYCLIC GEAR SYSTEMS—6/13/60

P55—DIGITAL STORAGE DEVICES—6/20/60

P56—EQUATIONS FOR 5 TAPERED CANTILEVER BEAMS—7/25/60

Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P37 P38 P39 P40 P41 P42 P43 P44 P45 P46
P47 P48 P49 P50 P51 P52 P53 P54 P55 P56

*MULTIPLE PRODUCT ADS	
Key No.	Specific Product

TAKE ADVANTAGE OF NEW LOW PRICE!

Have your own personal subscription to PRODUCT ENGINEERING sent each week to your office or home. You are then sure that you won't miss a single weekly issue. Further, each year of your subscription you will have your copy of the annual, thick Design Digest issue to read and refer to for years to come.

☐ 1 year—NOW $3 U.S. only* ☐ 2 years—NOW $4

*Canada
1 year—$5
2 years—$8

☐ Payment enclosed

☐ Bill me

Name ..... Title .....

Home ☐ .....

Address Office ☐ ..... Dept.....

City ..... Zone ..... State .....

Company Name ..... Product Mfgd.....

NEW CATALOGS AND BULLETINS

GENERAL ENGINEERING

365—Environmental Testing, 32 pp, Webber Mfg Co.

369—Radiation, 4 pp, R S Landauer Jr & Co.

METALS AND ALLOYS

356—Steel Tubing, 4 pp, Joseph T Ryerson & Son Inc.

367—Tubing and Bar Weight Comparison, 4 pp, Standard Tube Co.

376—Constant-modulus Tubing, 2 pp, Superior Tube Co.

NON-METALLIC MATERIALS, FINISHES

357—Polypropylene, 6 pp, Eastman Chemical Products Inc.

361—Cast Acrylic Rods and Tubes, 8 pp, Cadillac Plastics & Chemical Co.

373—Standard Resins, chart, Emerson & Cuming Inc.

MECHANICAL PARTS

351—Screw-thread Technology, 16 pp, H M Harper Co.

362—Liquid-level Windows, 4 pp, Bihur Lubricating Corp.

371—Brake-safety System, 4 pp, Kelsey-Hayes Co.

372—Vibration Isolator, 2 pp, Barry Controls Inc.

375—Pressure-reducing and Relief Valve, 2 pp, Atlas Valve Co.

FASTENING AND JOINING

353—Hydrogen Embrittlement in Fastenings, 7 pp, Standard Pressed Steel Co.

THIS WEALTH OF VITAL INFORMATION . . .

NEW COMPONENTS

GENERAL ENGINEERING

325—Technical Rubber Stamps

326—Drafting Machine

METALS AND ALLOYS

305—Color-coated Stainless Steel

NON-METALLIC MATERIALS, FINISHES

301—Silicone and Silicone-ceramic

303—Irradiated Polyolefin

POWER TRANSMISSION

300—Miniature, Flexible Four-way Coupling

302—Speed-reducers and Gearheads

307—Fhp Gearmotor

309—Variable 3:1 Speed Drive

MECHANICAL PARTS

319—Narrow Pillow-block Bearings

FASTENING AND JOINING

304—Sheetmetal Fastener

MOTORS, ENGINES AND CONTROLS

315—250 in.-oz Synchronous Motor

ELECTRICAL, ELECTRONIC COMPONENTS

306—Maximum Reading Meter

308—Temperature Detectors

310—Heavy-duty Lever Limit-switch

311—Rotary Switch

312—Explosionproof Proximity Switch

313—Switch Section

316—Cast Iron Footswitch

317—Temperature Controller

320—Miniature Heater

321—4-pole Contact Blocks

322—Insulated ¼-in. Thermostat

323—Plug-in Reset Timer

324—Wire and Cable Strapping

HYDRAULIC, PNEUMATIC EQUIPMENT

314—Split-flapper Check Valve

318—Directional Pneumatic Valve

MOTORS, ENGINES AND CONTROLS

354—Magnetic Drives, 11 pp, Gleason Reel Corp, Tormag Products Div.

364—Adjustable Electrical Speed Drives, 8 pp, Cleveland Machine Controls Inc.

374—Gas Combustion and Control, 8 pp, Bryant Industrial Products Corp.

ELECTRICAL, ELECTRONIC COMPONENTS

350—Dc Contactors and Relays, 32 pp, General Electric Co.

355—Terminal Blocks and Switches, 33 pp, Kulka Electric Corp.

360—Thermistors, 24 pp, Fenwal Electronics Inc.

363—Ac Potentiometers and Adjustable-function Generators, 12 pp, Perkin-Elmer Corp.

368—Capacitors and Relays, 4 pp, Schweber Electronics

377—Measurement and Control Products, 2 pp, Arthur C Ruge Assoc. Inc.

HYDRAULIC, PNEUMATIC EQUIPMENT

352—Rotary Gearpumps, 36 pp, Roper Hydraulics Inc.

358—Cylinders for Fluid Power, 12 pp, L & M Machine Co.

359—Couplings for Tubing, 4 pp, Aeroquip Corp, Marman Div.

366—Hose Clamps, 4 pp, Ideal Corp.

370—Centrifugal Pump, 4 pp, Corley Co Inc.

Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P37	P38	P39	P40	P41	P42	P43	P44	P45	P46
P47	P48	P49	P50	P51	P52	P53	P54	P55	P56

*MULTIPLE PRODUCT ADS	
Key No.	Specific Product

Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P37	P38	P39	P40	P41	P42	P43	P44	P45	P46
P47	P48	P49	P50	P51	P52	P53	P54	P55	P56

*MULTIPLE PRODUCT ADS	
Key No.	Specific Product

USE THESE PREPAID CARDS FOR

- More information on advertised products
- More data on new materials and components
- Copies of catalogs and bulletins offered
- Free editorial reprints
- Your personal subscription to PRODUCT ENGINEERING

Issue of August 1, 1960
PRODUCT
ENGINEERING
Card expires October 3, 1960

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Issue of August 1, 1960
PRODUCT
ENGINEERING
Card expires October 3, 1960

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

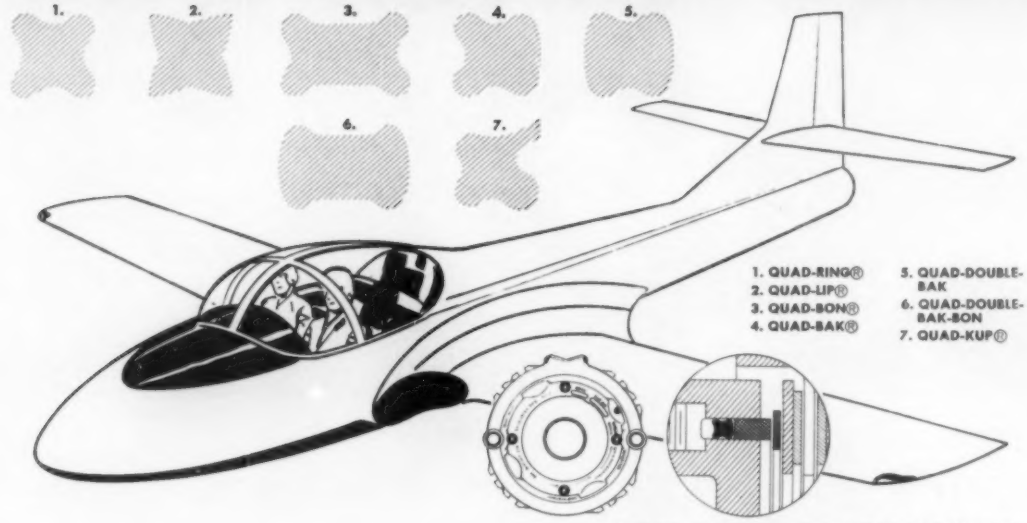
Information Sent Promptly

An Opportunity To Get More Information Quickly, Conveniently

MINNESOTA MR RUBBER

FACTS for FILING on

SPECIAL QUAD-RING® DESIGNS



Quad-Bak—used as a power-transmitting dynamic seal installed on the Auto Specialties Manufacturing Co. aircraft brake.

QUAD-RING® BASIS FOR THE DESIGN OF A WHOLE FAMILY OF VERSATILE SEALS

QUAD-RING—An exclusive development of Minnesota Rubber to give outstanding service in a wide range of dynamic and static sealing applications.

QUAD-LIP—Developed for applications which require zero leakage at very low pressure differentials with minimum mechanical interference.

QUAD-BON—Provides maximum resistance to spiraling in the smallest space possible while maintaining the sealing characteristics of the basic QUAD-RING.

QUAD-BAK—Designed to eliminate damage to packing when subjected to extreme extrusion in one direction only.

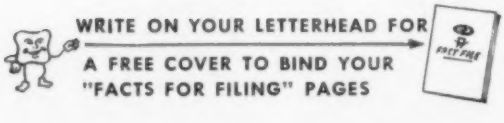
QUAD-DOUBLE-BAK—A double acting packing for maximum resistance to extrusion while maintaining two effective sealing lips.

QUAD-DOUBLE-BAK-BON—Provides maximum resistance to both spiraling and extrusion in a double acting installation.

QUAD-KUP—A unidirectional seal used where low friction is desirable but tolerances require a relatively large rubber-to-metal interference to take up for runout.

These special cross sections of the basic QUAD-RING design are just a few of the modifications possible to give complete versatility for any sealing application.

Manufactured under U.S. patents RE 24332 and 2,873,132, other patents pending.

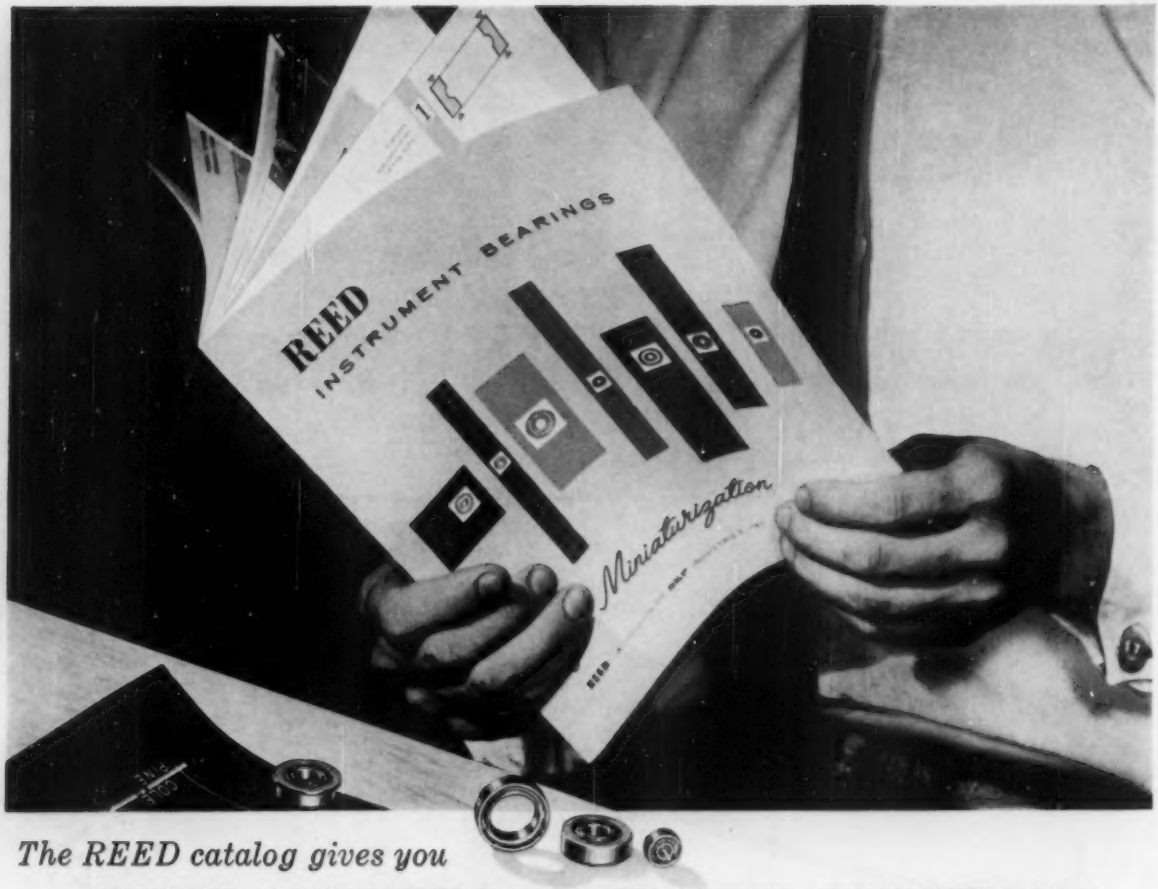


... WRITE MINNESOTA MR RUBBER

NFPA

DEPARTMENT 248, 3630 WOODDALE AVENUE
MINNEAPOLIS 16, MINNESOTA

CIRCLE 202 ON READER SERVICE CARD



The REED catalog gives you

QUICK ANSWERS TO TOUGH QUESTIONS ABOUT INSTRUMENT BEARINGS

Should we specify ABEC-7 instead of ABEC-5? What's the recommended lubricant: oil or grease? What shaft and housing tolerances shall we use? Should extended inner ring bearings be specified for the application?

Questions like these can fly fast and furious when you're on a project. That's exactly when you need REED's catalog on instrument bearings. Because, this small but specific reference combines valuable information with vital statistics on instrument bearings. There's no nonsense—just facts. Data on load ratings, fits, tolerances, etc. are all easy to find.

REED specialists are also readily available to help you with any bearing problem, large or small. These men are specially trained and experienced—fully able to make tiny bearings do big, important jobs. And they're located near you, as shown in the box at right. 6017

For a copy of the REED Instrument Bearing Catalog—or help with an instrument bearing problem—call or write:

REED Instrument Bearing Company
Div. SKF Industries, Inc.

•

4241 Redwood Avenue
Los Angeles 66, Calif.
Phone: UPton 0-5814 or
EXmont 8-3204

•

Front Street and Erie Avenue
Philadelphia 32, Pa.
Phone: GArfield 6-6400

•

29 Henry Street
Teterboro, N. J.
Phone: ATlas 8-1700 or
PEnnsylvania 6-9767 (N.Y.C.)

•

1800 N. 25th Avenue
Melrose Park, Ill.
Phone: FIllmore 4-1035 or
MAnsfield 6-7456 (Chicago)

REED INSTRUMENT BEARING COMPANY
LOS ANGELES, CALIFORNIA

Division of
SKF®
INDUSTRIES, INC.

CIRCLE 203 ON READER SERVICE CARD